BULLETIN
OF THE RESEARCH COUNCIL
OF ISRAEL
Section D
BOTANY

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CONTENTS

STUDY IN ATMOSPHERIC POLLEN IN JERUSALEM IN 1953—54[*]

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ABSTRACT

Airborne pollen was collected during the period from March 1953 to March 1954 at two observation stations in Jerusalem. The results reported were calculated per 1 day and 1 cm^2.

The main pollen contributors were: (a) *Cupressus, Pinus, Poterium spinosum* (February—April). (b) *Morus nigra, Olea europaea* and grasses (April—May). (c) *Casuarina, Ceratonia siliqua* in much smaller quantities (September—October).

Pollen of the entomophilous *Olea europaea* was found in considerable quantities. It deserves special interest as a possible allergen.

Poterium spinosum as contributor of air-borne pollen is mentioned here for the first time.

The pollen catches revealed absence or scarcity of pollen from several anemophilous plants, such as *Quercus, Pistacia* and others. Since these plants grow in the vicinity of Jerusalem, it is evident that the dispersion area of their pollen is quite restricted.

Studies of atmospheric pollen are of both botanical and medical interest. Pollen is of paramount importance for the genesis of allergic diseases, being the main cause of hay fever, many cases of asthma and a few cases of dermatitis. The allergist has to know which pollen is found in his locality. Skin testing in combination with a pollen calendar will enable him to find the cause of an allergy. Desensitization with the incriminated pollen may cure the patient.

Pollen surveys are being carried out systematically in various countries. In Israel a pollen survey was published by Kessler (1951—52) and results of two other studies are in preparation. Gutman (1941, 1950) compiled lists of hay fever plants of Palestine. He found that here grass pollen — especially that of *Cynodon dactylon* — is the most important pollen as far as allergy is concerned.

The study presented here was carried out from March 1953 to March 1954. In this survey the plants are listed in the order of pollen quantities irrespective of their importance as allergens.

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METHODS AND SITES OF OBSERVATION

Pollen catches were made at two stations in Jerusalem. Station A was on the roof of the 20 m high Connaught House close to the Old City walls. The house is surrounded by commercial buildings, but a small municipal garden, mostly of mulberry trees is just in front of the house, and the Russian Compound with its olive and pine trees, is less than 200 m away. Station B was on the roof of a 12 m high house in the residential quarter of Rehavia, on the western outskirts of the city, bordering on olive groves and open spaces of natural vegetation. Various trees are grown for ornament near the houses. The two stations are about 1½ km apart (see sketch map, Figure 1).
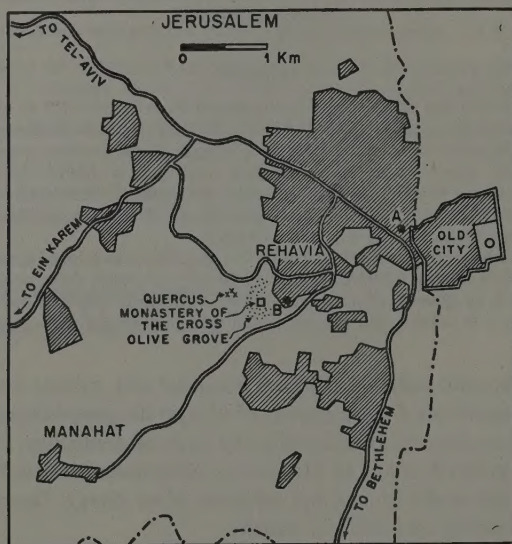
Figure 1
Sketch map of Jerusalem indicating observation stations (A and B)

Slides were exposed on a standard collector used by the U.S. Academy of Allergy (Vaughan and Black 1948). The slides were coated with glycerine jelly (1½ : 1) stained with basic fuchsin (Wodehouse 1935) and exposed, with several exceptions, every 48 hours. In 1954 the vaseline method was used and a drop of Calberla's solution was applied before covering with the coverglass (Vaughan and Black 1948). Identification of the pollen was carried out with the aid of Wodehouse (1935) and Erdtmann (1943, 1952), but mainly by comparison with pollen taken from plants collected in Jerusalem during the observation year and mounted in glycerine jelly as above. The quantities of pollen counted were calculated per one day and 1 cm².

FLORA AND VEGETATION OF JERUSALEM

Phytogeographically Jerusalem is situated on the eastern border of the Mediterranean territory of the country and close to the Irano-Turanian territory. Natural vegetation comprises scattered fragments of Maquis (the *Quercus calliprinos—Pistacia palaestina* association) and much more extensive areas of Batha (dwarf-shrub associations with predominance of *Poterietum spinosi*), as well as rock vegetation. Olive groves are rather extensive in the city and its surroundings. Various trees are grown for ornament, the most prominent being *Cupressus* sp., *Pinus halepensis*, *Ceratonia siliqua*, *Ailanthus glandulosa*, etc. Waste places with ruderal plants are numerous, and walls are often covered with plants, such as *Parietaria judaica* and *Hyoscyamus aureus*. Grasses belong mainly to the Batha associations, irrigated crops being almost non-existent near Jerusalem.

RESULTS

The following plants were recognized among the pollen types:

A. Main pollen contributors

(1) *Cupressus*. This genus is the foremost both in pollen quantities and in the length of pollen production. Large pollen amounts were found in March — April 1953 and in January — March 1954. Small pollen quantities appeared also in May, June, September and October. Three species of this genus are grown near houses: *C. sempervirens* (var. *horizontalis* and var. *pyramidalis*), *C. macrocarpa* and *C. arizonica*. *C. sempervirens* is the most common.

Durham (1954) reports cases of allergy due to *Cupressus* pollen, but these cases are very rare.

(2) *Pinus*. Pine pollen was second in abundance. It appeared in March and April, the flowering time of the main pine species — *Pinus halepensis*. At Station B, pine pollen was recorded somewhat earlier than at Station A. Small amounts of pine pollen were also found on the slides in May, June and August, presumably from pollen deposits scattered by wind. Single specimens of *Pinus canariensis* are grown in Rehavia.

Pine pollen to all intents and purposes is not allergenic. The pollen is coated with a waxy layer which is not attacked by the nasal mucosa (Gutmann, unpublished).

(3) Grasses. The total pollen quantities are considerable though significantly lower than those of *Cupressus* or *Pinus*. The main season of grass pollen in 1953 was from the beginning of April to the middle of May. Smaller quantities were found until the end of July in Station A and until the middle of September in Station B. No attempt was made to identify species or even genera.

Some remarks may be added on the grasses common in or near Jerusalem *Cynodon dactylon*, which Gutmann (1950) recognizes as the most important all

country, is rather scarce in Jerusalem. It flowers mainly during the summer months, The most common grasses of the Batha around Jerusalem are *Avena sterilis, Hordeum bulbosum, H. spontaneum, Oryzopsis holciformis, O. miliacea, Dactylis glomerata, Poa bulbosa, Bromus* spp. Common ruderal grasses are *Hordeum murinum* and *Lolium perenne.*

(4) *Olea europaea.* Olive trees are grown in and near Jerusalem. Considerable pollen amounts were found in both stations from the beginning of May to the middle of June. The season is short, it starts and ends rather suddenly. There was some difference in the peak of the curve at the two stations (Figures 2 and 3). Since the olive tree is known to be entomophilous, the high pollen amounts found on the slides suggest that it is wind-pollinated at the later stage of the anthesis of each flower when the pollen becomes dry and dusty.

Olive pollen is recorded as allergenic in California (Vaughan and Black 1948) and in Israel (Gutmann 1950, Kessler 1951—52), and owing to its amount it certainly deserves special consideration.

(5) *Morus nigra.* Mulberry trees are grown in various parts of the city, the majority being female. A group of male trees growing close to the site of Station A caused rather large pollen deposits to be recorded in this station during April and the first half of May. The scant *Morus* pollen found in Station B indicates that its deposition area is rather limited.

In U.S.A. the related *Broussonetia papyrifera* is regarded as an important allergen (Durham 1954, Vaughan and Black 1948). Gutmann (1950) listed *Morus* among the allergenic pollens.

(6) *Poterium spinosum* (Rosaceae). This is the main component of the Batha (dwarf-shrub) association *Poterietum spinosi.* Its male flowers produce fair quantities of anemophilous pollen, which is however also collected by bees. The flowering season is from February to the end of April. The pollen amounts recorded at Station B, which is close to the Batha area, are significantly higher than those recorded at Station A.

Being an East-Mediterranean species, *Poterium spinosum* has not as yet been recorded as a contributor to airborne pollen, and its allergenic value is still to be found out.

B. Plants which contributed small pollen amounts
(a) Trees

(7) *Ceratonia siliqua.* Pollen of the Carob tree appeared on the slides from October to the middle of November. The small quantities found despite the common occurrence of male trees in the town indicate that they are not wind-pollinated.

According to Gutmann (1950), no allergic sensitivity to carob pollen was found.

(8) *Casuarina cunninghamiana* is grown mainly as an avenue tree. Its pollen deposits, though small, are characteristic of the autumn season (September to October, at Station B till November).

In Florida, *Casuarina* pollen caused a few cases of allergy (Durham 1954).

(9) *Quercus calliprinos*. Though several trees of this oak species grow about ½ km from Station B, only traces of its pollen were recorded. This, despite the anemophilous habit of the species.

(10) *Pistacia* (Anacardiaceae). Several large trees of *Pistacia atlantica* grow close to Station A, and shrubs of *P. palaestina* grow near the oak trees mentioned above. Despite the fact that these plants are known as wind-pollinated, almost no pollen of this genus was recorded in this survey.

(11) *Schinus molle* (Anacardiaceae) is common near houses as an ornamental tree. A few pollen grains were recorded in summer. The tree is insect-pollinated.

(12) *Eucalyptus rostrata* is somewhat less common than the last. Some pollen grains of this insect-pollinated tree were recorded from June to August.

(b) Shrubs and herbs

(13) *Hyoscyamus aureus* (Solanaceae). Common on walls throughout the city. An entomophilous plant flowering mainly in spring. Pollen was recorded from April to November at Station A and from April to September at Station B.

(14) *Nicotiana glauca* (Solanaceae). This adventitious small tree or shrub is common in waste places and on walls. It is pollinated by insects. Single pollen grains were found on the slides.

(15) *Parietaria judaica* (Urticaceae) is a common species covering shady walls near Station B. Despite its anemophilous pollen, only few pollen grains were found.

(16) Chenopodiaceae. The common ruderal species are *Chenopodium murale* flowering in spring and *Atriplex rosea* flowering in summer. Despite their anemophilous habit, only scattered pollen grains were recorded.

(17) Amaranthaceae. *Amaranthus blitoides* is a summer annual, common in waste places and near roadsides. Other *Amaranthus* species are scarce owing to lack of irrigated crops. Several pollen grains of this family were recorded.

(18) Compositae. Various genera are found throughout the year as common wild or cultivated plants. Nevertheless, only a few scattered pollen grains of Compositae were found, mainly in summer.

The well known allergenic *Ambrosia* and *Artemisia* species do not grow in Jerusalem. However, since according to Durham all Compositae pollen is potentially allergenic, it seems that the reaction to direct contact with flowers of this family should be studied.

(19) Labiatae and (20) Umbelliferae. The pollen grains of both families are very characteristic. Pollen of the Labiatae was recorded in spring, that of Umbelliferae somewhat later in the season. Both were found in small quantities.

TABLE 1

Monthly totals (I), daily averages (II) and annual totals of pollen grains referred to 1 cm².

Each cell shows **I** (monthly total) and **II** (daily average). Station **A** and Station **B** are given as separate rows for each taxon.

No. of days of observation	Station	1953 March (12 / 9) I	II	April (25 / 17) I	II	May (31 / 31) I	II	June (30 / 6) I	II	July (25 / 31) I	II	August (25 / 31) I	II	September (24 / 30) I	II	October (31 / 31) I	II	November (13 / 21) I	II	December (17 / 15) I	II	1954 January (31 / 17) I	II	February (28 / 6) I	II	March (9 / 11) I	II	Total
Cupressus	A	1142	95	444	18							8	0.3	8	0.3	24	0.8	8				80	2.6	117	4.2	93	10	1834
	B	835	93	235	14							18	0.6			25	0.8	6		3		233	14	30				3091
Pinus	A	258	22	781	31	204	6.5	25	0.9			14	0.6	4	0.1	11	0.4							29		93	10	1071
	B	285	31	444	26	243	7.8					8	0.3			5	0.2	2	0.1					1				817
Morus nigra	A			156	6	46	1.5																	3				174
	B			2	0.1	4												1		1				5	0.1			6
Casuarina	A					47	1.5																					25
	B					18	0.6																					16
Olea europaea	A					38	1.2																					212
	B					26																						265
Ceratonia siliqua	A					70	2	15	0.5	4	0.1	2	0.1	3	0.1	3	0.1	2	0.1	1								6
	B					170	5.5	3	0.5	2	0.2	2	0.1					1	0.1									9
Poterium spinosum	A	15	1	45	0.7	0.4		0.5	0.5	4	0.4																	63
	B	16	2	0.5	2.5			0.3	0.5	2	0.2																	150
Gramineae	A			12		0.4		15	0.5	2	0.1					5								3				152
	B			0.7	2.5			3	0.5	4	0.4					11								1				304
Pistacia	A			87	2			3	0.5							7	0.2											0.9
	B			0.5												5	0.2							5	0.1	10		0.7
Quercus calliprinos	A			0.7		0.5		0.3		4																		0.6
	B				2.5					3.4																		7.7
Schinus molle	A					5.1		1.3		0.4		1.4																9.8
	B					2.3	1.3			1.8	1.3	0.3																0.2
Eucalyptus	A			0.2				1.3		0.4		0.9					1	0.5										1.6
	B			0.5						0.9		2.3																6.5
Parietaria	A			0.2		0.9				1.1		0.3	0.9				0.8		0.2									3.3
	B			0.5		0.2		0.6		1.1		0.3	0.9						0.8									5.1
Chenopodium	A									0.6																		6.3
	B									0.4				0.4		1		0.2										5.3
Amaranthus	A					2.5				0.4		2.3						0.2										5.4
	B					1.9				0.9		0.3						0.8										5.6
Polygonum	A			0.2				0.3		0.4		0.9				1		0.4										6.2
	B			0.5						0.9		2.3		0.8				0.8										
Hyoscyamus aureus	A			0.7								0.6		0.4		0.5		0.4										0.7
	B																			0.3						0.6		0.6
Nicotiana glauca	A			1.6																								7.7
	B			0.2														0.8										9.8
Umbelliferae	A			0.5		0.9		1.3		0.6																		0.2
	B			0.5		0.2				0.4		0.3				1		0.2										1.6
Leguminosae	A			1.1												1		0.2										6.5
	B			1.1				0.6				0.9				1		0.8										3.3
Labiatae	A			1.8		1.6		3.2																				3.3
	B			0.5														0.5										
Compositae	A	1		23		57		2		2		0.6		2.4				2						29		93		13.6
	B			4.5	0.3	4.6	3.4	0.5		0.6		3.4		0.9				0.5		0.7				3	5	10		23
Type X (unidentified)	A	2		5	4.2	1.6	3.4	0.5		0.6		0.6		2.4		2.5	2.2	2		0.7		0.5	0.5			1.6		62
	B			4.2	4.5	2.6						3.4		0.9														15.8
Unidentified	A				0.3	1.8	0.8																					24.3
	B					2																				4.2		
Total	**A**	**1418**	**118**	**1500**	**60**	**399**	**12.8**	**102**	**3.4**	**20**	**0.8**	**8**	**0.3**	**18**	**0.3**	**24**	**0.8**	**6**	**0.5**	**1**		**81**	**2.6**	**60**	**4.3**	**93**		**3621**
	B	**1136**	**126**	**795**	**46.8**	**578**	**18.6**	**20**	**3.3**	**26**	**1**	**18**	**0.6**	**23**	**0.6**	**25**	**0.8**	**8**	**0.4**	**3**	**0.2**	**237**	**14**	**121**	**10**	**1790**	**0.3**	**4796**

(21) Unidentified. Apart from several unidentified pollen types which were signi-
ficant in amounts, one pollen type recorded in May in both stations was prominent
in quantity. It could not yet be identified.

The results of the pollen counts and identifications are summarized in Table I,
in which monthly and total amounts and daily averages are recorded for each of
the stations. Figures 2 and 3 show diagrammatically the variation in the pollen
amounts for the main pollen contributors during the observation period. Figure 4
shows the main pollen distribution throughout the year.

<div align="center">DISCUSSION</div>

<div align="center">*Seasonal variation*</div>

Two seasons of pollen deposition could be distinguished: (a) Spring (March to
May and the beginning of June) with large pollen amounts and many contributing
species. This season was preceded by a short winter season (January—February)
characterized by *Cupressus* pollen. (b) Autumn, which was much poorer in every
respect. The trees contributing were *Casuarina* and *Ceratonia*. Otherwise, during the
summer and the first winter months (June to December) only negligible amounts
of pollen were found.

The period of pollen deposition varied in length for different species. *Cupressus*
pollen had a long deposition period, conforming to its long flowering season. The
pine has a short but very intensive pollen season. Pine pollen also appeared on the
slides long after the close of the flowering time, apparently from places where pollen
accumulated in spring. The long season of grass pollen is mainly due to the succession
of flowering of different grass species. The olive tree, *Poterium spinosum* and the
mulberry tree have each a short season of pollen dispersion, starting with large
pollen quantities and ending suddenly.

<div align="center">*Comparison of spring* 1953 *with spring* 1954</div>

The winter of 1952—53 was dry at the beginning. The main rainfall was in February
and March and as a consequence spring flowering was late and scarce. During the
next winter (1953—54) rains fell abundantly and at regular intervals. Temperatures
were low in winter and high in spring, resulting in early and abundant flowering.

These differences are reflected in Figure 4. Pine and mulberry pollen appeared
much earlier in 1954 than in 1953. Similarly, pollen of *Poterium spinosum* at Station B
appeared in the second half of February 1954 in quantities much higher than in
March 1953. Pollen of *Cupressus* declined almost one month earlier than in 1953.
Grass pollen appeared in 1954 about 20 days earlier. On the whole, the spring
flowering season was about one month earlier in 1954 than in 1953.
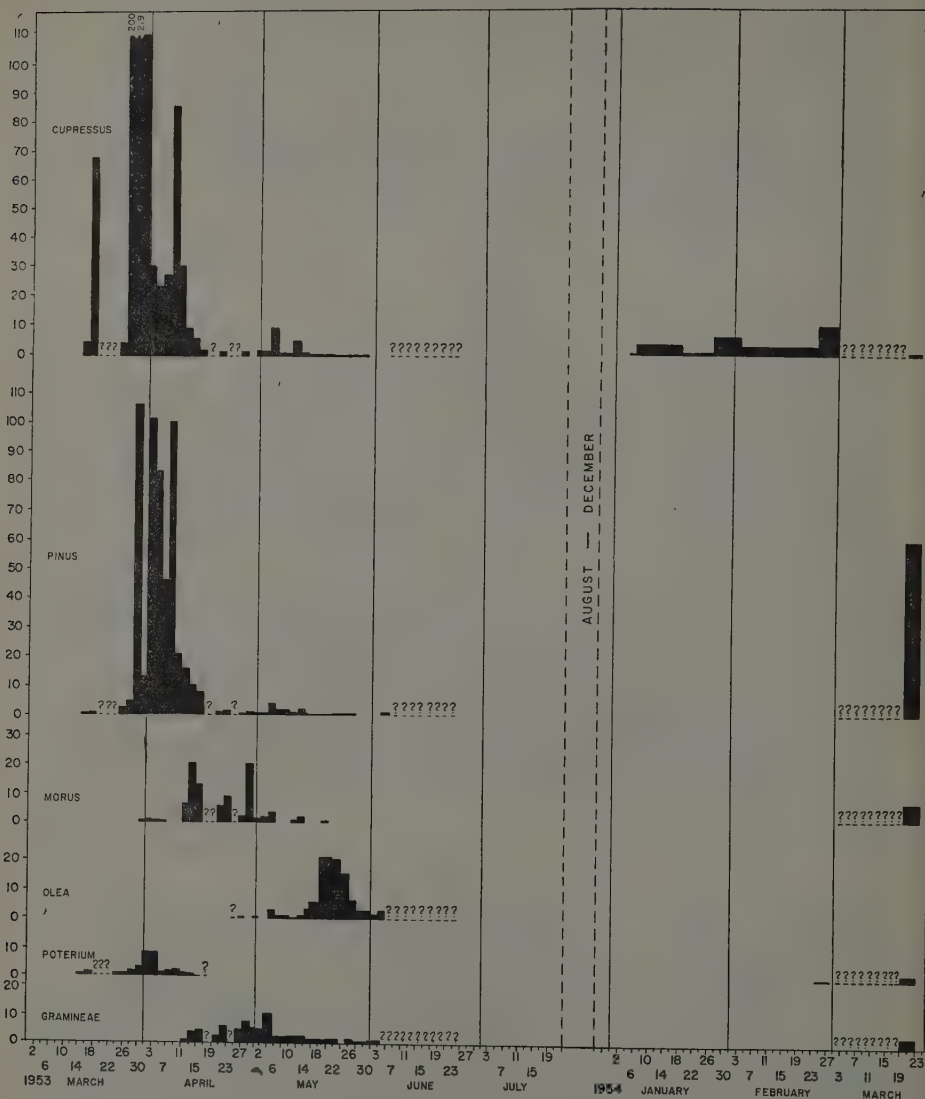
Figure 2

Graph of pollen catch in Station A twice daily during the period 6. III. 1953 — 23. III. 1954, calculated for day/cm². Question marks indicate days when no slides were exposed.
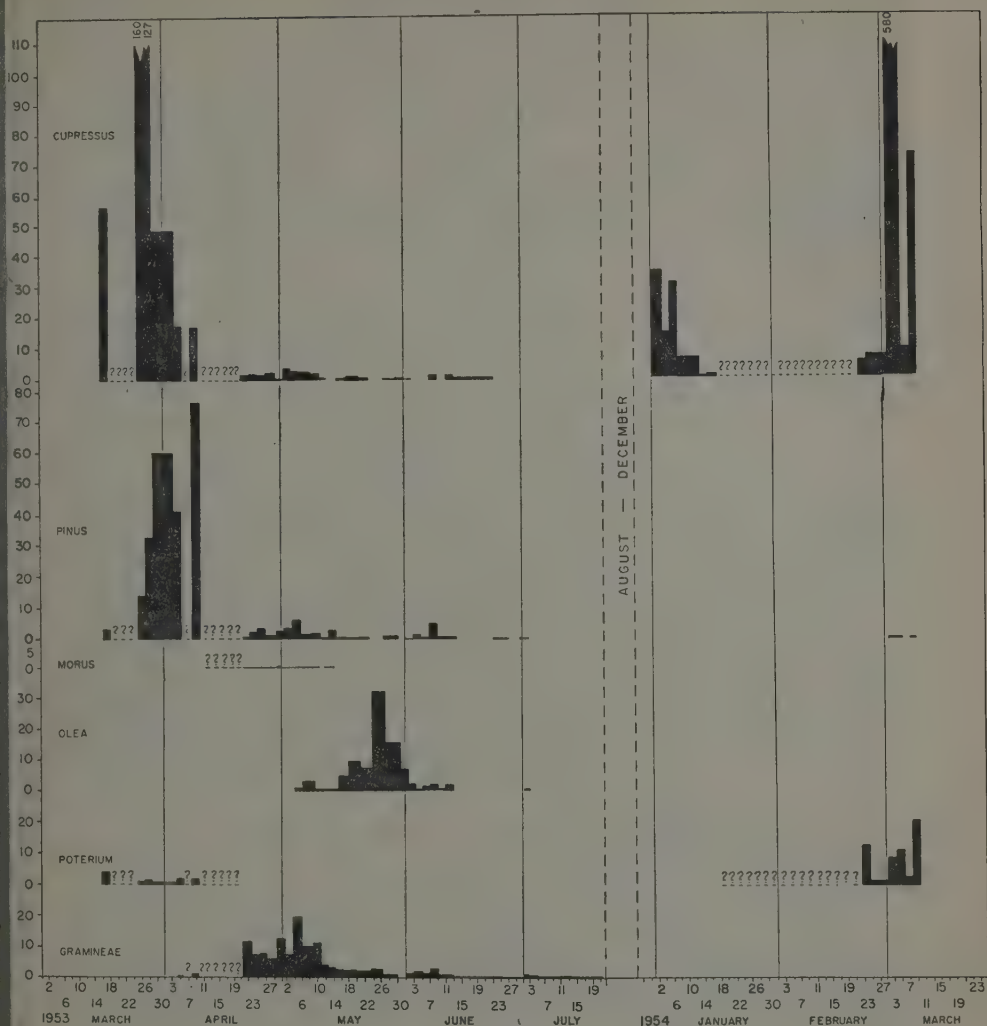
Figure 3

Graph of pollen catch at Station B twice daily during the period 16. III. 1953 — 10. III. 1954,
calculated for day/cm². Question marks indicate days when no slides were exposed.

Figure 4

Variation in the deposition rate of the principal pollen types at both observation stations (A and B). Heavy line — more than 4 pollen grains found per day/cm²; thin line — 1-4 pollen grains per day/cm²; broken line — less than 1 pollen grain per day/cm², but finds continuous.

Pollen quantities and their variation

The highest pollen counts were those of *Cupressus* and *Pinus*. Much lower but still considerable were the pollen quantities of grasses, the olive tree, the mulberry tree and *Poterium spinosum*.

The average daily amounts obviously do not reflect the variation in pollen amounts deposited during the 24 hours. Airborne pollen may prove to be much higher than average at certain day hours, thus raising the allergenic value of certain pollen species.

Comparison of the pollen catches at the two stations

The differences in the situation of the two stations are reflected in the frequencies of different plants. Pollen deposits from plants of the Batha such as grasses and *Poterium spinosum* were found at station B much earlier in the season, lasted longer and reached higher amounts than at Station A which is surrounded by taller buildings and at a fair distance from open spaces of natural vegetation. On the other hand, pollen deposits of the mulberry trees were much higher at Station A.

The differences in quantity and composition of pollen catches at the two stations, as well as the extreme scarcity or lack of some pollen types, such as *Quercus calliprinos*, *Pistacia*, *Parietaria* and other anemophilous plants, emphasize some striking facts important for both allergists and botanists: (1) The importance of the plants growing in close proximity to the station of observation. (2) The restricted area of pollen deposition even in anemophilous plants. It is apparent that even comparatively low barriers such as shrubs, rocks, stone walls, etc. can prevent the spread of pollen from the pollen producers to distances exceeding a few hundreds or even tens of metres. The local character of pollen deposits is pointed out by Hyde and Williams (1944, 1945, 1946) and Hyde (1950a, 1950b, 1952).

Entomophilous species as contributors of airborne pollen

Most prominent is *Olea europaea* with the total of 711 and 879 pollen grains caught during the observation period at Stations A and B respectively. Entomophilous species with far lower pollen deposits were *Ceratonia siliqua*, *Schinus molle*, *Hyoscyamus aureus*, *Nicotiana glauca*, and a few others.

In our survey no pollen of *Ailanthus glandulosa* was found, despite the fact that a male tree grows close to Station A. Durham (1954) mentions it among several other entomophilous trees which are not important as allergens. In this connection it is noteworthy that Tas (1956) found positive reaction to *Ailanthus* pollen in several cases. It is however clear that pollen of *Ailanthus* is not carried by wind and is allergenic only through close contact.

COMPARISON WITH OTHER OBSERVATIONS MADE IN THE MEDITERRANEAN OR SIMILAR CLIMATES

(a) Tel-Aviv. Kessler (1953) records total pollen and pine pollen amounts for Tel-Aviv which are much lower than ours from Jerusalem. He found no pollen deposits

of *Olea*, *Poterium* or *Morus*. Tel-Aviv is much more extensive in area than Jerusalem and poorer in natural vegetation. Pine and olive trees are less numerous. Ornamental trees and shrubs, mostly entomophilous, did not show up in the pollen catches. On the other hand, irrigated crops are common near the city, and pollen of weeds of the Amaranthaceae family is quite prominent.

(b) Giv'at Haim (Sharon Plain). Data on atmospheric pollen collected by Mrs. M. Yaffe will be published shortly. Owing to the rural character of the Station situated in the midst of irrigated crops and of natural plant association of *Desmostachya* (*Eragrostis*) *bipinnata*, grass pollen is abundant. Pollen of trees abundant in Jerusalem is almost absent. The summer and winter catches are much more abundant in general.

(c) Lisbon, Portugal (Pinto da Silva 1955). The seasonal rhythm is very similar to that of Jerusalem. In February and March, *Cupressus*, *Pinus*, *Platanus*, *Celtis* and *Ulmus* were common. In April and May, *Quercus* and *Olea europaea* (mostly in May) appeared, while in June to July grass pollen was predominant. From August to October very little pollen was caught, mainly of Chenopodiaceae and Amaranthaceae. Almost no pollen was found in November and December. The main difference from the pollen catches in Jerusalem was the occurrence of pollen from the genera *Quercus*, *Ulmus*, *Celtis*, *Platanus*, the absence of *Morus* and *Poterium spinosum*. The grass pollen season is late in comparison, the summer months being cooler and moister than in Jerusalem.

(d) Los Angeles, California (Targow 1948). The total quantities are smaller, apparently owing to the larger area of the town. Similar catches are those of *Pinus*, *Cupressus*, grasses and the olive tree. Olive pollen is considered allergenic (Vaughan and Black 1948). Grass pollen is found throughout the year, mainly between March and September.

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FURTHER OBSERVATIONS ON ROOTS PENETRATING INTO ROCKS AND THEIR STRUCTURE

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ABSTRACT

Continuing his studies on Mediterranean maquis shrubs growing on bare rock and disintegrating it, the author observed figs, Aleppo pine, Arbutus and others on the steep rocky slopes of the sea-canal of Corinth. Observations in Israel (Mt. Carmel) showed that roots growing outside preexisting fissures are mainly found in soft or porous rock, and that lentisks and oaks rather than carobs are responsible for this phenomenon. Lentisks and Palestine buckthorn finally crack boulders after germination in tiny depressions.

The identification of the roots in question as such of pistacias in the vast majority and of oaks in a few cases became possible by anatomical studies of roots of Palestinian kermes oak, carob, lentisk, *Phillyrea* and Palestinian buckthorn, the anatomy of which is described in some detail. Colour and structural peculiarities of the cortex (sclerenchymatous tissues or bodies, phloem fibres, mastix ducts) and the phelloderm (shape, arrangement and elastic properties of the cork cells) were found to be of great diagnostic value.

INTRODUCTION

In a paper read before the Congress of Mediterranean Botany at Nice the present author (Oppenheimer 1954) drew attention to the fact that roots of certain Mediterranean maquis shrubs penetrate into calcareous rocks, dissolving them by the excretion of acid substances. He advanced the idea that the species mainly responsible for the phenomena observed was the lentisk (*Pistacia lentiscus*), but no definite proof for this hypothesis could be offered. In the present article some additional observations are described, and definite proof of the above statement obtained from studies of root structure is presented.

FIELD OBSERVATIONS

1. Passing through the sea-canal of Corinth by boat, we observed, on its steep slopes, Mediterranean trees and shrubs rooting in the soft limestones and marls. Among these, we mention the Aleppo pine — which had earlier been found by us penetrating into intact, soft limestone rock (2) —, the lentisk, the abundance of which is very striking, the fig tree (*Ficus carica*), and the oriental strawberry tree (*Arbutus andrachne*). While the fact that seedlings of these species — originating from seeds spread by wind, water or birds — strike roots on slopes with inclinations of about 70 % is in itself interesting, we do not know whether rooting in this case

taket place in the intact rock or in preformed fissures. The same doubts arise in respect of the South American bush *Nicotiana glauca* observed here, too, on very steep slopes, together with two lithophytes, *Phagnalon* (?) *graecum* and *Capparis spinosa*, which were also noted by us as rock plants at the Acropolis of Athens.

Incidentally, we wish to remark that the covering of the rocks by plants on the steep escarpments of the Canal of Corinth is still in its initial stage, and a denser pioneering associes composed mainly of *Inula viscosa* and *Oryzopsis miliacea*, which is very characteristic for the locality, evidently presupposes a smaller inclination and perhaps also softer or easily cracking layers of rock or soil.

2. The main area of our observations remained the western slope of the hill bearing on its top the colony of Zikhron Ya'aqov (Israel). Its vegetation is mainly composed of the *Ceratonia siliqua—Pistacia lentiscus* association, shading off into the nearly related association of *Quercus calliprinos—Pistacia palaestina*, especially in northern exposure. A closer analysis of the petrographic character of the rocks by Dr. M. Ben-Yair disclosed that the slopes consist of hard limestones and dolomites of the Cenomanian and of their weathering products. The softening of the rocks leads to products of a granular, porous texture, which often crumble if crushed in the hand. But there are also soft limestones — apparently weathering products — resembling Senonian chalks, and conglomerate rocks composed of hard limestone boulders embedded in a softer chalk. Further, one finds marls and nari crusts. The softening of the rock is often pronounced to a depth of many metres.

When the road connecting the colony with its railway station in the coastal plain was broadened in 1954 — an enterprise which involved deep cuts into the maquis stocking on the rock — we were offered an excellent opportunity to study root growth in the various strata of the rocks (Figures 1 and 2). Boring machines driven by compressed air, and dynamite opened these strata, making observation easy.

Networks of roots appearing on the fresh surfaces laid open for observation had often developed in fissures, while in other cases, the unblemished and unweathered condition of the rock left no doubt that the roots had grown in the intact rock. A careful survey of the conditions of rooting in the new side-walls of the road led to the following conclusions: (1) Active growth occurs mainly in the porous, crumbling type of rock or in the soft chalk. In conglomerate rocks, one often meets roots spreading at the periphery of the hard boulders. Only in one case did we find a fragment of hard limestone penetrated by roots, and this occurred in the immediate neighbourhood of an oak tree. (2) Not all species of the maquis vegetation grow in intact rock, but this occurs mainly near lentisks and oaks. While roots of carobs caused corrosion of soft rocks in some cases, no active penetration into the rocks could be established in any case, though large trees were present the root systems of which had been laid open. While the observations on the new escarpment which covered many hundreds of square metres, definitely seemed to corroborate our previous impression that active penetration into rocks is mainly due to the activity of the lentisks, it was still difficult to prove this definitely, since in most cases the

roots could not be traced back to their origin, having been torn into pieces during the operations in the rock. Thus it became necessary to undertake investigations into the internal structure of these roots in the hope of detecting differential criteria allowing their identification. These studies form the subject of the following main paragraph. Meanwhile a few further observations concerning the development of shrubs and trees in rocks are mentioned here. Lentisks were found germinating on the surface of rocks in very tiny depressions. Development is poor in a first stage, but finally the rock yields to the pressure of the growing roots and the base of the trunk, and it happens that large boulders projecting above the neighbourhood split in their middle. Sometimes horizontal plates are flaked off. Later on, the development proceeds at a speed which would appear normal for trees rooting in rocky soil. Besides the lentisk, we found the Palestine buckthorn (*Rhamnus palaestina*) germinating in small cavities of rocks and eventually cracking them. In one case a trunk of *Rhamnus* had reached afterwards a diameter of 20 cm. *Phillyrea media* also germinates in such cavities, but so far, we did not see it splitting rocks. Lifting of rocks by growing trunks and their roots was observed in large specimens of carobs and oaks. This may even be effected by trees growing beside rocks, however, and does not imply that the trees grew before in the rock and cracked it. Generally speaking germination in cavities of small size on rocks would seem to presuppose small seeds readily germinating after rains, but would hardly be expected with oaks or carobs. Olives do not seem to be able to grow in the solid rock, as we could again state at Jerusalem when large scale blowing of rock took place on a site planted with old olives, for the construction of a basement. The roots were seen to ramify into fissures and pockets filled with soil, without attacking the limestone rock itself. This is in line with recommendations of French experts (Bonnet) to shatter rocky substrata of sites to be planted with olives by dynamite, in order to produce fissures and thus to render deep rooting possible.

3. Further interesting observations were made by others. D. Koller, of The Hebrew University of Jerusalem, observed a thick lentisk root piercing a large cliff at Iqzim (north of Zikhron Ya'aqov in the Carmel hills), and he could definitely state that there were no preformed fissures. S. Illan of Lehavot Habashan (Upper Jordan Valley) noted root penetration of *Pistacia atlantica* and *Zizyphus lotus* growing in this region into solid basaltic rock, and G. Gefner reported on penetration of eucalypts (*E. camaldulensis* and *E. robusta*) also into basaltic rocks at Kfar Yeladim (Esdraelon Valley). The strength of eucalypt roots is well known, and they are even credited with the power to penetrate through concrete walls and to lifting foundations of houses. Dr. Ben-Yair, who, at our request, made observations in Scandinavia, arrived at the conclusion that active penetration of roots into the eruptive granites (and schists) widespread in Sweden and Norway is a rare phenomenon. It was observed in some unidentified dwarf bushes in Sweden. These bushes growing on shallow soil layers above granite wilted early during spells of dry weather since,

unlike the above-mentioned porous calcareous rocks of the cretaceous period, the rocks possessed no water storing capacities.

<div align="center">ANATOMICAL STUDIES</div>

<div align="center">(a) General</div>

4. While the interest in forest products and wood technology has produced a vast literature dealing with the gross and minute structure of trunks and branches of trees, information on the anatomy of their roots is remarkably poor, as stated by Riedl (1937) in a paper on the root anatomy of Central European forest trees. While he found that the roots of the species studied had diffuse-porous wood even if the aerial axes were ring-porous, and that their histological components like xylem parenchyma and libriform fibres varied considerably in the roots of the same specimen, he found the colour of those roots and particularly of their peripheric layers often highly characteristic and useful for their identification. The latter statement seems to be true also for our Mediterranean forest trees.

Before entering into a detailed description of the roots studied by us, we wish to make some general statements. While the distinction of plants by their roots appears as a difficult and often hopeless undertaking when first visualized, a thorough study reveals numerous distinctive characters which finally render the task easy to the experienced observer. Our experience comprises at present only 1 to 5 millimetre thick roots of a restricted number of species.

The root surface is distinguished by colour and structure. The roots can be smooth or rough, their surface reticulate or fissured. They can be covered by many or few layers of rhytidome, i.e. dead cork layers. Their external appearance may show various tints of brown, grey, black or red, distributed either uniformly or unevenly, as in the root of *Rhamnus palaestina*. In the dry state, this root looks whitish. Under a hand-lens, however, one distinguishes older peripheric layers alternating with younger depressions. The former are whitish, the latter reddish black.

The structure of the periderm is of great diagnostic value in the species studied by us. The walls of the still living cork cells can be colourless (*Phillyrea media*) or yellow (carob, lentisk), their contents colourless to yellowish, as in the pistacias and the carob, or brown as in the oaks. Their shape is either very flat (oaks) or slightly flattened to square (*Pistacia*), regular or changing in neighbouring rows, and their arrangement either strictly leveled, both in radial and tangential rows, as in the carob (Figure 5), or irregular and mainly alternate, as in the pistacias, or intermediate (oaks).

In the secondary cortex, we find an extreme structural diversity. As a rule, there are hard, opaque sheaths of sclereids, i.e. strongly thickened sclerenchymatous, $\pm$ isodiametric cells, often developing from ordinary cortex parenchyma. These sheaths are either thick and continuous, as in *Phillyrea media*, or rather slender and interrupted, as in *Pistacia lentiscus* and *Ceratonia*. They may form columnar bodies

in longitudinal orientation, as in *Rhamnus palaestina*, and can be interspersed with or surrounded by crystal bearing idioblasts. Pericyclic fibres are either present, as in the carob and oak, or absent, as in *Pistacia lentiscus*, *Phillyrea* and *Rhamnus*. A very characteristic feature of the pistacias are their inner cavities lined with a secretory parenchyma producing the resin-like mastix. The latter can be stained emerald green with copper acetate (Francehenet-Unverdorben reaction). Further the cortex parenchyma may contain cells rendering tannin reactions or showing distinct colours, as reddish brown in the peripheric cells of the oak cortex or butter-yellow in *Rhamnus palaestina*. These colours strike the eye at a macroscopic examination of cross- and lengthwise sections, as does also the fox-red colour of the contents of moribund and dead cells in the cortex of *Pistacia palaestina*. The large size of the parenchymatous cells is of diagnostic importance in *Quercus calliprinos* while a collenchyma-like thickening of the tangential walls in certain cortex layers sometimes strikes the eye in the root of *Pistacia lentiscus* (Figure 6).

The conducting secondary phloem offers few striking examples of differentiation, but the elements of the secondary xylem are of great diagnostic value, in spite of the great variability of its composition. Pores may be relatively large, reaching diameters of 100 microns and more, as in the carob, oak and sometimes in *Pistacia lentiscus*, or narrow (less than 60 microns), as in *Phillyrea* and *Rhamnus*. They form very varying proportions of the cross-section. We found them surrounded by vasicentric tracheids or small vessels. Their walls may be mainly reticulate (*Pistacia*) or densely covered with bordered pits, as usual in carobs or *Rhamnus*. Their arrangement is always scattered, but there may be a restriction to certain areas and a faint radial or tangential arrangement. The smaller wood cells are mainly vasal parenchyma, as in the carob, or starch-storing substitute fibres, as in *Pistacia*, or else true libriform fibres, as in *Rhamnus*. Bundles of fibres are kept apart from the vertical parenchymatous tissue in the carob, but are intimately interwoven, forming ribbons or small groups of a few cells each in *Quercus calliprinos*. The xylem rays strike the eye if crossing fibre tissue as in *Pistacia*, or are inconspicuous, as in the carob where they are surrounded mainly by parenchyma with optical properties similar to those of themselves. Of course, their breadth, height and composition can often be used to advantage for diagnostic purposes.

It is obvious that a definite determination of roots of unknown origin collected in the field presupposes, strictly speaking, the intimate knowledge of the morphological and anatomical features of roots of all the species growing in the neighbourhood and their variations in the same species. Difficulties arise in particular in the identification of roots of the same genus, e.g. in *Pistacia*, *Quercus*, *Rhamnus*, represented in the Palestinian maquis by more than one species. Our aim was modest: above all the establishment of reliable anatomical characters for the distinction between the roots of the carob and the lentisk which are similar to each other, on one hand, and the evergreen oak on the other. Expanding the scope of our investigation a little further, we have accumulated data on the structure

of roots of these and a few other species which, though incomplete, seem to warrant publication.

(b) Specific root structure

5. *Quercus calliprinos* (Figure 4). Root surface dark purplish brown to black, with lengthwise running thin strips of dead bark in young, and thick scales separated by horizontal and vertical cracks in old roots. Periderm composed of small flat cells with thin yellow or whitish walls and orange yellow to chestnut brown contents. Outer cortex colourless or bright orange red, composed of large parenchymatic cells, 30 to 50 μ across with polyedric to oval starch grains of unequal size, up to 17 microns across. Parenchyma of inner cortex colourless or partially orange-yellow, interspersed with small bundles of wide (30—50 μ) sclereids with radial pits, small, anastomosing bundles of bast fibres (25 μ) and longitudinal aggregates of cells with single or compound crystals, possibly identical with Hartig's "Kristallkammer-fasern" (1869).

Vessels few, solitary, in obscurely radial arrangement, 30—50 μ across, with slash-like or bordered pits, or reticulate, sometimes occluded by tyloses. Wood parenchyma cells (12—14 μ) and fibres (15 μ) with thick walls (5 μ) arranged in small groups, form in cross-section a mosaic or net-like pattern, with meshes formed by tangential, one cell broad bands of longitudinal parenchyma as warp and similar looking wood rays as woof, surrounding fibre islets. Flat sheaths of vasicentric parenchyma surround the vessels.

Remarks: (1) The orange-brown substance of the peripheric layers is easily washed out in water from the living root. This is of diagnostic value. (2) In cross-sections, the rigid periderm has a pronounced tendency to reach out, tearing apart from the tissue beneath.

6. *Ceratonia siliqua* (Figure 5). Colour of the minutely reticulate-fissured root dark brown, sometimes with blackish or reddish hues; cork layers composed of many, rather large (15×30—45 μ), strictly rectangular cells, 2 to 3 times broader than long, in regular radial and concentric arrangement. Outer cork cells with dark brown, inner with yellow walls and colourless to dirty brownish contents. Cortex white at its periphery, with a mixed sheath of scleroids and idioblasts containing rather small single crystals; inner cortex with numerous fibres of varying width (9—24 μ).

Metaxylem of cream colour with darker centre; vessels of medium density, scattered in vaguely radial arrangement, occupying, as a rule, 5—10% of the cross-section, but sometimes considerably more, with slash-like or bordered narrow pits in thick (6—14 μ) walls. Their breadth fluctuates considerably, the largest, at the roots' periphery, attaining about 175 μ. Length of the rectangular, simply perforated vessel segments about 190—270 μ. Large vessels often surrounded by smaller, flattened ones which are 20—40 μ broad, and vasicentric parenchyma. Tracheids apparently lacking. The main body of the metaxylem is composed of separate large

bundles of distinctly septate wood parenchyma and fibres, the former usually pre-dominating and often packed to capacity with starch grains. The cells of these tissues are 30—50 μ broad. Broad fibres with relatively wide lumen are able to store starch. Rays 1- to 5-seriate, sometimes heterogeneous in the sense of Reinders-Gouwentak (1950), rather high (until 22 storeys observed), with thick (2—4 μ) walls and numerous, very small, roundish or slit-like pits.

7. *Pistacia lentiscus* (Figure 6). Colour of the root reddish-brown, blackish or red, with smooth surface, if fresh and young. Periderm strongly developed, with rather large cells of mainly rectangular shape, in various proportions of breadth and length (e.g. $25 \times 45 \mu$; $23 \times 29 \mu$; $20 \times 18 \mu$), in irregular arrangement. Outer, dead cells with brown, inner with bright, lemon yellow walls. Cell contents colourless to light dirty brown. Outer cortex — especially in thicker and older roots — with bright red cells, isolated or in contiguous layers, which often strike the eye if a shallow cut is made into the root. Further inwards follows an interrupted sheath of sclereids in groups, mixed with crystal cells containing single or compound crystals. Medium and inner layers often with collenchyma-like cells, forming ribbons of tangentially thickened walls and with cell groups or lenticular cavities containing mastix. No fibres have been observed.

Metaxylem whitish, except the cream-coloured or brownish centre, sometimes with a violet hue if fresh. Pores scarce to very numerous, single or twin, in indistinct tangential arrangement and often connected by aggregates of metatracheal vascular tracheids. Diameter of medium vessels 60—90 μ, of large ones 100—140, composed of elements with simple perforations, 120—220 μ long. Tracheids 17—32 μ broad, often with spiral, sometimes anastomosing thickenings. The bulk of the metaxylem is composed of substitute fibres serving both storing and mechanical ends (breadth 11—17 μ). They form tangentially or radially arranged aggregates. Rarely one meets septate parenchyma with very delicate cross-walls. Rays mostly 1-seriate, the broader 2- to 5-seriate, homo- or heterocellular with erect cells at the ends, about 150—400 μ high, composed of 10—30 tiers.

REMARK: Foot structure of *Pistacia Palaestina* is very similar to that of the former species. The yellow walls of the young periderm cells and their irregular arrangement, as well as their inner mastix glands in the cortex illustrate this point. However, there seems to be more xylem parenchyma. In our preliminary observations, We further saw a pronounced growth ring produced by differences in the frequency of vessels, and in the radial extension of the smaller xylem elements. The matter requires further study.

Roots of *Pistacia lentiscus* growing in fissures often become extremely flattened, looking ribbon-like in cross section (Figure 7). Microscopic examination revealed an abnormal structure in the elliptical to linear cross-section. While in the normal root, the rays follow straight or slightly undulating courses, they are partially deflected in those ribbon-like roots. Here, only the rays coinciding with two main axes of the cross-section remain straight, the others being deflected to directions approaching right angles to the walls of the rock. It seems quite possible that this growth reaction of the living ray tissues helps the root to press on the rock and

finally to burst it open. Pfeffer (1893) who studied the energetical aspects of the problem, not only insisted on the fact that the ribbon-like deformation of roots growing between rigid plates, raises their pressure in the cross-wise direction, but also calculated pressures exerted by such roots in rocks. However, he did not study the structure of deformed tree roots and their energetic implications.

8. *Phillyrea media* (Figures 8 and 9). Root surface reticulate, of two colours: greyish and whitish. The ridged meshes are greyish-yellow to greyish brown, the lower lying fissures whitish. Cross-sections look yellowish under a hand lens, especially the woody core. The cork cells have colourless walls which turn dark near the surface only. They are rather flat (breadth-length index 3:1) with rounded corners and irregularly arranged. In the intermediate zone of the storage tissue of the cortex with its large starch grains (10μ) we found a strongly developed ring of sclereids, with large cells (30μ), reminding those of the oaks. These cells are often found also at the outer edge of the cortex, adjoining the phellogen. Apparently, there are no fibres.

The secondary xylem is extremely hard, reminding in its structure that of the citrus trees. Vessels very narrow (30—40, rarely 60 μ)* and restricted to certain areas of the cross section, in indefinite, somewhat tangential arrangement (Figure 8). They occur either single or in multiplies of 2 to 3 and have thick (6 μ) walls with densely packed bordered pits. Fibres polyedric in cross-section (15 μ) form the bulk of the woody core. Tangential narrow ribbons of longitudinal parenchyma and numerous, mainly uniseriate rays cross it. Under strong magnification, growth rings appear which are produced by differences in the radial diameter of the fibres and by the terminal parenchymatous bands (Figure 9).

9. *Rhamnus palaestina*. Root surface reticulate-fissured, black if moist, dark grey with an elevated whitish reticulate superstructure, if dry. In cross-sections, one perceives under a hand-lens a brown cortex with lemon-yellow spots and a quince-yellow wood core with brown centre. Under the microscope, one easily distinguishes exterior dark and dead layers of the periderm from inner, living bright ones. The cortex is spotted with butter yellow, cylindrical cells and interrupted by the above mentioned rods of sclereids which, if seen in lengthwise sections, evince a facet structure. No phloem fibres were observed. In the wood, one sees solitary pores in restricted areas, scattered or in obliquely radial arrangement, surrounded by vasicentric parenchyma. The vessels, often elliptic in cross-sections, reach diameters of 50 μ only. Their walls are crossed by pits with very small and pronounced borders. They are composed of cellular elements with simple, round perforations. The bulk of the secondary xylem is composed of strongly thickened fibres with secondary yellowish and tertiary whitish (gelatinous?) layers. Rays are uni- or pluriseriate (biserial, as a rule) with about 20 tiers of procumbent or erect cells

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* Rouschal (1937), probably investigating older roots, found somewhat wider vessels (46—77 μ) while his indications for those of the root of *Pistacia terebinthus* (107—150 μ) resemble our findings in *P. lentiscus*.

With the aid of the above anatomical data, it could be definitely established that the roots growing outside preexisting fissures, belonged to Pistacias, very probably to *Pistacia lentiscus*, as could easily be demonstrated by the arrangement of their periderm cells and the possession of mastix ducts. All roots of a relatively large diameter (2 mm and more) isolated from rock fragments found near Zikhron Ya'aqov were Pistacia roots. Only in a few cases, thinner roots were identified as oak roots.

We trust that the above, so far incomplete descriptions of root structure will prove useful to others interested in the identification of roots of Mediterranean maquis species. In the further course of these studies, we hope to develop a key for the determination of these and other roots.

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Figure 1

Roots of oaks and other maquis shrubs disintegrating the uppermost layer of the calcareous rock below a very thin or non-existent soil layer by the side of the road from Zichron Jacob to the railway station.

Figure 2

Roots of oak (*Quercus calliprinos*) above and *Capparis spinosa*, on the left, below, unveiled by operations of the Public Works Department next to the road from Zichron Jacob to the railway station. Deep vertical penetration in contrast to conditions in Figure 1.
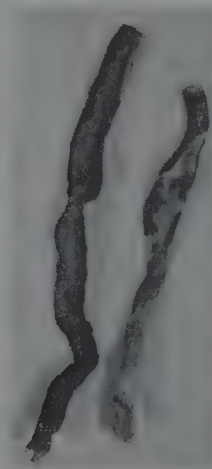

Figure 3

Ribbon-like roots of *Pistacia lentiscus*, misshapen by the conditions of growth in narrow fissures of rock.
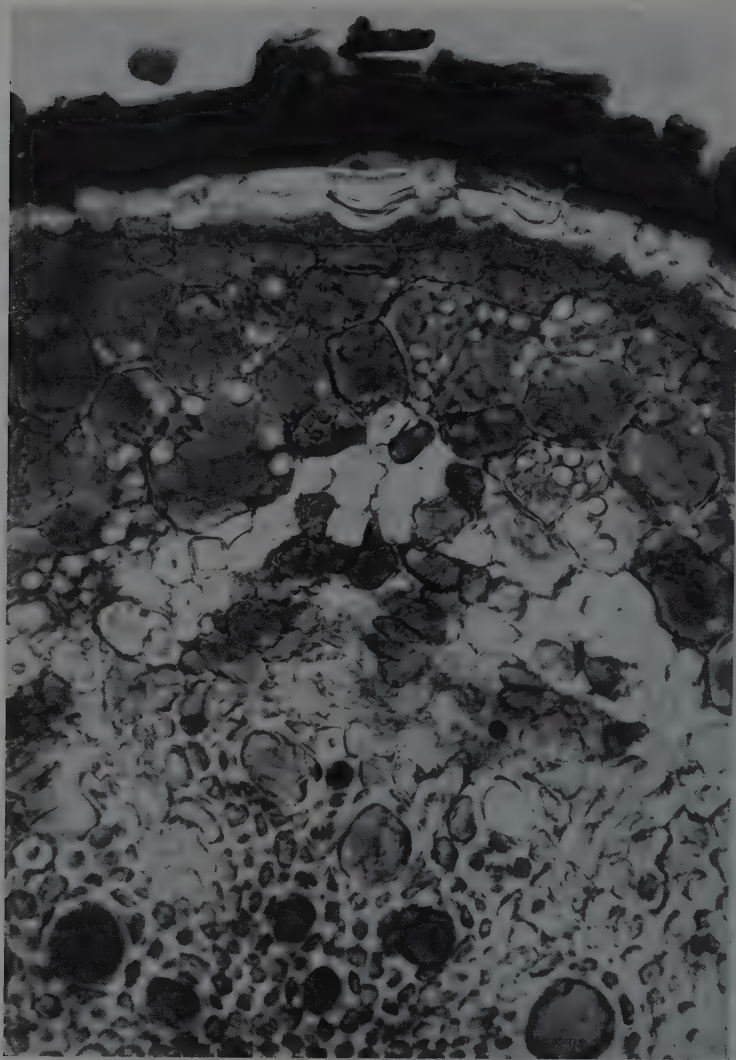
Figure 4

Cross-section through the cortex of a young root of *Quercus calliprinos* showing: (1) dark cork cells, bright phellogen and half-tone phelloderm, (2) large, half-tone (reddish-brown) parenchyma cells with starch grains, (3) sclerenchymatous coalescing bundles with sclereids, thick-walled bast fibres and crystal bearing cells, (5) below centre: conducting phloem with sieve tubes, (6) Xylem with isolated vessels.   × 450.
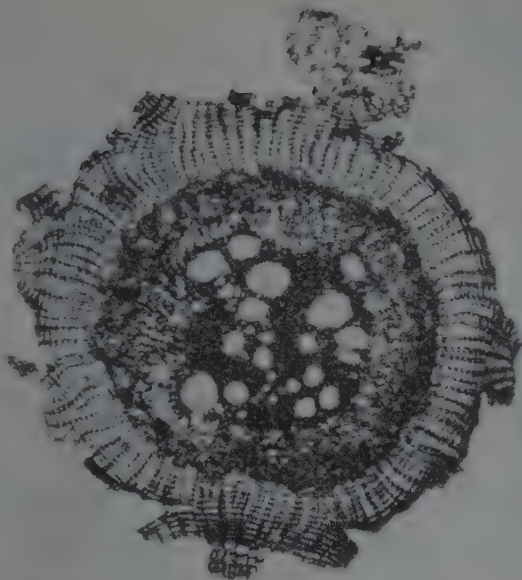
Figure 5

Cross-section through the root of the carob tree (*Ceratonia siliqua*) showing the geometrically regular arrangement of the cork layers. × 65.
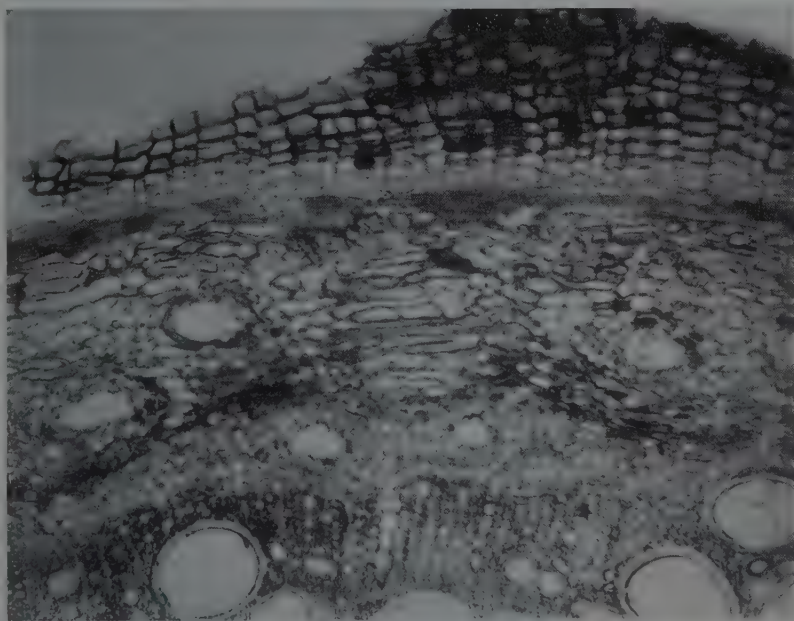

Figure 6

Cross-section through the outer portion of the root of *Pistacia lentiscus*. (1) Cork tissue of irregular structure, (2) cortex parenchyma forming an interrupted, dark (actually bright red) outer layer, (3) sclereid-crystal cells layer with oblong sclereids, mainly in tangential orientation, (4) inner cortex with mastix ducts and collenchymatous layers, (5) xylem with vessels, tracheids and small cells which are mainly substitution fibres. × 110.
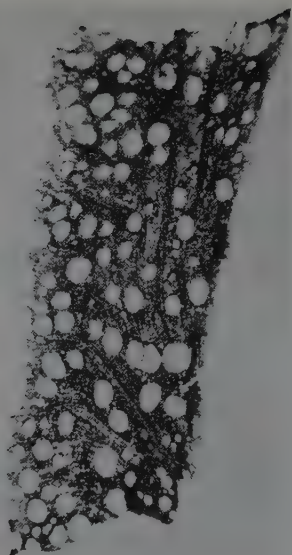
Figure 7

Cross-section through quadrant of a ribbon-shaped root of *Pistacia lentiscus*. The centre, marked by smaller vessels, in the right, lower cornerf Indistinct wood rays running in the direction o' the main axes evince a normal, straight course' but intermediary rays are abruptly deflected to the direction of the shorter axis. × 100.
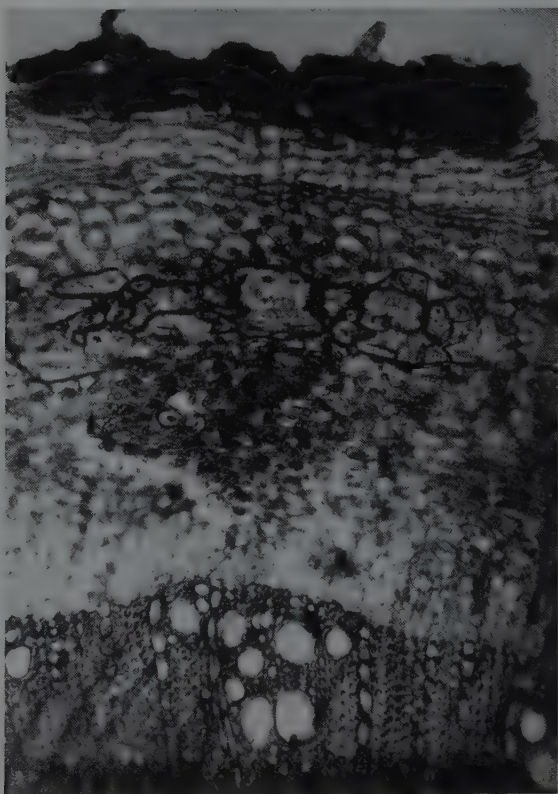
Figure 8

Cross-section through the outer portion of the root of *Phillyrea media*. One easily distinguishes dark, dead and bright, living cork cells. A ring of sclereids divides the cortex into an inner and an outer portion. In the wood, areas rich and others poor in vessels. × 110.

Figure 9

Cross-section through the secondary xylem of the root of *Phillyrea media*. It shows intercrossing zones of parenchyma surrounding thick-walled wood fibres and vessels. × 225.

THE BEGINNING OF CELL DIVISION AND CELL ELONGATION IN GERMINATING LETTUCE SEED

Michael Evenari, Shimon Klein, Hannah Anchori and Naomi Feinbrun

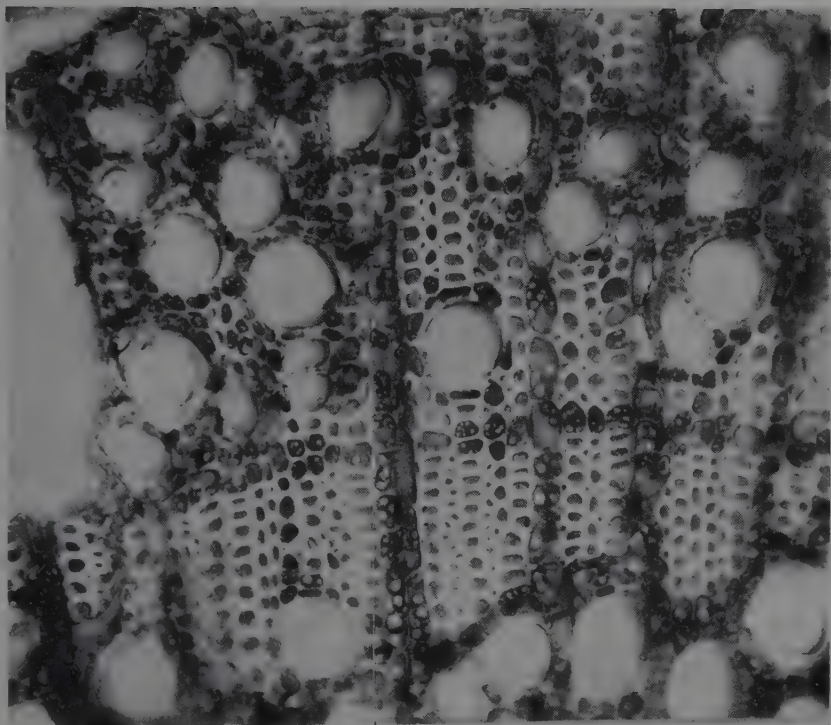*Department of Botany, The Hebrew University of Jerusalem*

ABSTRACT

1. The first mitoses appear in lettuce seeds germinating at 26°C during the 13th hr of imbibition.

2. The mitoses reach a maximum at the 16th hr. From there on to the 20th hr there is a steady decrease.

3. The start of mitoses, the beginning of cell elongation and the protrusion of the rootlet are correlated events during germination.

In connection with our work on the germination of seeds it was important to know at what time after the start of imbibition the cells of the embryo begin to divide and elongate. Such a timetable of germination is needed in order to try to coordinate certain known physiological phases of germination with definite morphological changes inside the embryo. On this subject there seems to be very little knowledge and we found only one paper dealing with this question (Goo 1952). As most of our research on germination is carried out with lettuce seeds, we also used lettuce seeds, var. Grand Rapids, for our investigation on the beginning of cell division and elongation.

METHOD

The seeds were germinated in Petri dishes in water in the dark at 26°C. After two hours of imbibition they were illuminated for 3 minutes with an incandescent lamp of 250 f.c. This illumination guarantees full germination (Evenari 1952, Evenari and Neuman 1953). They were then put back into dark.

After different time intervals in the germinator, the seeds were fixed in Carnoy's or Lewitsky's fixation fluids after removal of seed and fruit coats. After the paraffination, 12 microns thick longitudinal sections of the whole embryo were mounted with collodion on slides (see Schommer 1949, p. 70), and stained with Feulgen's Leuco-basic Fuchsin.

RESULTS

The first mitoses appeared during the 13th hr of imbibition. We never found a single mitosis before this time, not even a prophase, though we looked carefully through the slides of 24 seeds fixed 12 hrs after the start of imbibition. The time of the first mitosis coincides with the beginning protrusion of the root through the seed and fruit coats.

The first mitoses were localized in the periblem at a distance from the root cap. During the 14th, 15th and 16th hr of imbibition, the zone of mitoses extends down to the root cap and cell divisions appear even in the plerome. Table I shows the number of mitoses in the median section of one seed at different times,

TABLE I

Number of mitoses observed in median sections of 5 seeds after 13—20 hrs of imbibition

Seed	Hrs after imbibition						
No.	13	14	15	16	17	18	20
1	5	11	15	23	16	10	8
2	2	12	18	20	14	12	10
3	4	8	12	17	14	8	7
4	4	10	15	25	21	14	9
5	4	5	17	16	24	11	10
Average	3.8	9.2	15.4	20.2	17.8	11.0	8.8

It is obvious from this table and the data on earlier stages that the number of mitoses rises from zero in the 12th to a maximum in the 16th hr. From there on to the 20th hr there is a steady decrease.

Next we wanted to know at what time the root as a whole starts elongating. To this end we measured in median sections the distance from the calyptrogen to the point where the procambium branches off into the cotyledons.

Table II gives the average results of these measurements.

TABLE II

Length of roots during germination

Hr of imbibition	0	6	9	10	11	12	13	14	15	16	17	18	20
No. of sections measured	(8)	(9)	(7)	(8)	(9)	(24)	(11)	(5)					
Average length in mm	9.72	8.64	8.99	8.96	8.88	9.22	12.96	14.35	12.60	14.71	19.26	17.33	20.31

An analysis of the data did not show any significant difference in the length of the roots between 0 and 12th hr, whereas the figures for the 13th and 14th hours are significantly different from each other and from the figures of the previous hours.

This means that the root as a whole starts elongating during the 13th hour at the time when the first cell divisions appear. The elongation continues even while the number of cell divisions decreases (see the figures for the 16—20 hr in Table II).

This elongation may be accounted for either by an increase in the number of cells, or by cell elongation, or by both.

In order to clear this point we counted the number of cells comprised in one row of the periblem from the calyptrogen to the branching of the procambium.

The results are summed up in Table III. The analysis of variance showed significant difference between the number of cells from zero hr to 12 hrs after the start of imbibition at one hand and the 13th and 14th hr on the other.

TABLE III

Average number of cells in one row of periblem in median section of roots

Hrs of imbibition	0	6	9	10	11	12	13	14
No. of seeds investigated	8	8	6	8	7	22	11	8
Average no. of cells	87.6	87.2	89.0	87.1	90.9	90.0	98.5	98.3

In Table IV we give the average length of cells (in microns) at different hours after imbibition.

TABLE IV

Average length (in microns) of cells from periblem of roots

Seed No.	Hrs of imbibition							
	0	6	9	10	11	12	13	14
1	113.8	86.5	87.7	96.9	105.7	98.3	131.9	142.8
2	100.0	84.6	99.7	101.7	102.6	102.6	155.9	145.9
3	96.3	92.1	96.1	94.4	93.0	135.3	117.4	136.2
4	111.5	103.4	94.4	92.1	90.1	89.8	127.5	62.0
5	112.7	92.4	—	—	91.5	96.5	122.6	145.8
Average	106.8	91.8	94.5	96.3	97.3	104.5	131.1	126.5

Analysis of variance showed that there is no significant difference for the figures from 0 to the 12th hrs, whereas the figures for the 13th and 14th hrs are significantly different from those of the preceding hours. This means that cell elongation starts only after the 12th hr.

The results of the last two measurements may be summed up by saying that the increase in the number of cells and the elongation of cells are two simultaneously occurring processes which in seeds germinating normally bring about the protrusion of the roots through seed and fruit coat.

Up to now we dealt with seeds which were germinated under conditions guaranteeing their full germination. When seeds are sectioned, the germination of which is prevented by keeping them at 26°C in darkness without illumination, not a single cell division and no cell elongation is observed even 24 hrs after the start of imbibition.

DISCUSSION

From previous investigations of one of us (Klein 1955) we know that at 26°C and after treatment with white or red light the first roots emerge from the seed at the 13th hr and that about 50% of all seeds germinate between the 14—16th hrs after
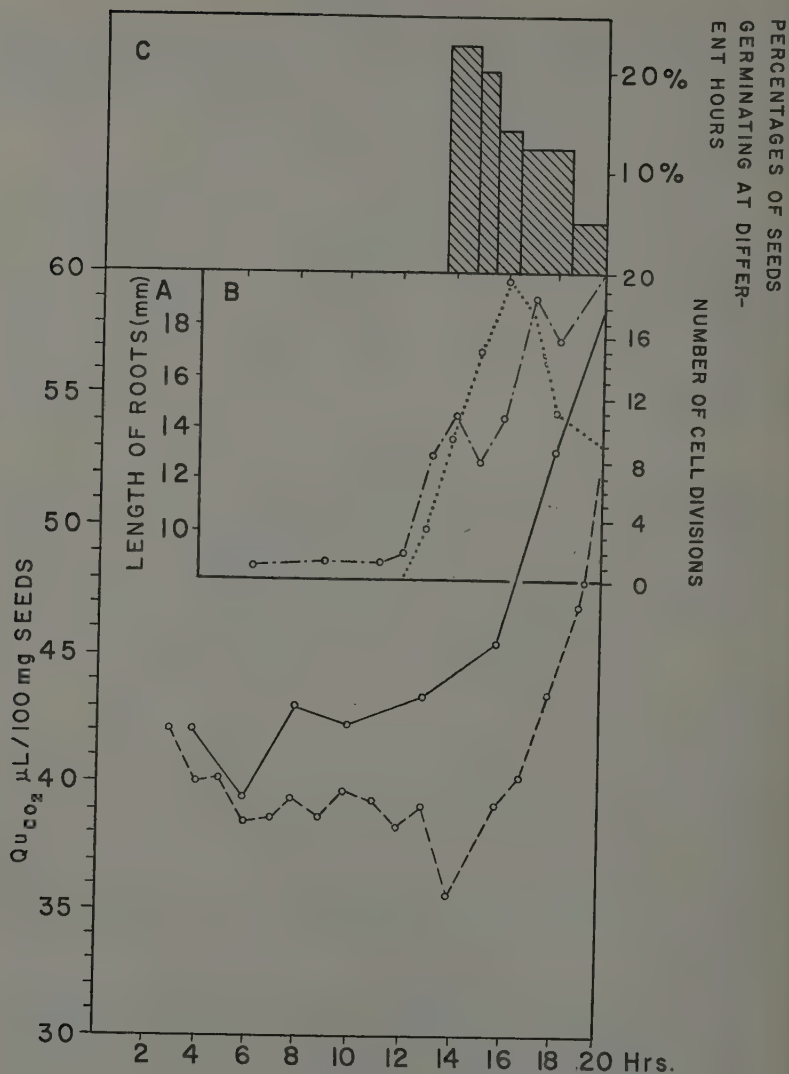
Figure 1

A. Both curves represent the respiration rate of germinating lettuce seeds at different times after imbibition.

   The scale 30—60 gives the Q_{CO_2} ((μl/100 mg seeds)

B. .... Number of cell divisions in roots at different times of imbibition. The scale belonging to this curve is on the right side (0—20).

   —.—.—.—.— Length of roots in mm. (Left scale 10—18).

C. Percentage of lettuce seeds germinating at different times after imbibition.

the start of imbibition (see Figure 1C). This means that the start of mitoses, the beginning of cell elongation and the penetration of seed and fruit coats by the rootlet are correlated events. The maximum of cell divisions is reached at a time when about 50% of the seeds have germinated.

There is a further correlation which emerges when we compare the curve of respiration with that of cell division and elongation. In Figure 1A we chose among our many respiration measurements (Evenari, Neuman and Klein 1955), 2 different curves for Qu_{CO_2}. In the case of one curve the coincidence between the rise in respiration rate and the onset of cell division and elongation is very outspoken. In the other case there is a time lag between the two groups of events. However, in seeds which do not germinate an initial rise of respiration rate was noted (Evenari, Neuman and Klein 1955) which subsided after some time, though no cell divisions or cell elongation could be found. The decrease in number of cell divisions after the 16th hr is another puzzle which can perhaps be accounted for by an endogenous periodicity of mitoses. This assumption would disagree with Bunning's (1952) statement that there is no periodicity of mitoses in roots free of chlorophyll. On the other hand, it is in con- formity with our experience of a marked daily mitosis rhythm in onion root tips. Fixations of onion root tips for class work in cytology showed for many years that the best fixation time in Jerusalem was about 10 a.m., whereas the afternoon hours were distinctly unsuitable for the purpose. This observation corresponds well with that of Margot (1956), who found a daily variation of the number of mitoses in lentil roots grown in complete darkness.

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THE INFLUENCE OF *TAMARIX APHYLLA* ON SOIL COMPOSITION IN THE NORTHERN NEGEV OF ISRAEL

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ABSTRACT

In order to examine the effect of *Tamarix aphylla* trees on soil composition under desert conditions in the Northern Negev, soil samples taken from under the canopy of the tree and nearby in the open were analysed for total soluble salts, chlorine and organic matter content. It was found that all three values were higher under the trees than in the open.

There was no such effect on soil composition by *Acacia cyanophylla* trees.

The composition and spatial arrangement of the flora surrounding old Tamarix trees reflect the more saline conditions under their canopy.

INTRODUCTION

Tamarix aphylla (L.) Karst. and to a lesser extent *Tamarix jordanis* var. *negevensis* (Ehrb.) are used extensively for afforestation of sand dunes in the northern Negev. It is remarkable that a permanent ground litter is formed under Tamarix trees in spite of the arid conditions prevailing in the region, and the question therefore arises to what extent does it affect the soil composition.

The effect of ground litter on the soil composition in arid zones has so far received very little attention. Fireman and Hayward (1952) working in Utah, U.S.A., found that certain bushes growing in the desert appreciably increase soil salinity as well as the *p*H of the soil solution in their immediate vicinity. Moreover, there was a decreasing gradient of both *p*H and salt content of the soil from the base of the bush outwards as well as in the depth. They concluded that these changes in soil composition were caused by the litter. Killian (1944) and Vargues (1953) found accumulation of humus and nitrates as well as a development of a rich microflora in the soil under certain desert plants, not accompanied by any accumulation of chlorides. As the Tamarix species in question are salt excreting plants (Marloth 1887, Volkens 1887), it would be interesting to find out whether there is any difference between the soil composition under the plants and in the open, as a result of the high salt content of the litter itself and the salt crust coating of the green branches which is washed out to the ground either by rain or by dripping dew drops.

In the present study, soil samples were taken under the canopy of Tamarix trees and nearby in the open. Samples were analysed for organic matter, total soluble salts and chlorides. Samples were also taken under the canopy of *Acacia cyanophylla* in order to compare this plant with Tamarix. In addition, an attempt was made to correlate soil composition under the canopy to the age of Tamarix plants.

LOCALITY

The work was carried out during the winter of 1954 in the area of moving sand extending across the northern part of the Negev. Two stations were selected: the Government Forest 13 km south of Beersheba and the JNF Forest 6 km northwest of Revivim. The Tamarix plantations are mostly confined to the dunes. The plants are shrubby, 3—4 metres in height. There are also solitary specimens of *Acacia cyanophylla* with no litter underneath.

The attempt to correlate the age of the trees with the soil composition was made with some bigger trees in the sandy stretches between Revivim and Halutsa. Their origin, whether planted or natural, is not known.

METHODS

Soil analyses

Soil samples were taken from depths of 0 to 5, 40 and 80 cm, and occasionally also from 20 cm. Two diggings were made at each site, one under the canopy, within the litter covered area; the other as close as possible in the open. In several cases an additional digging was made under the canopy of *Acacia cyanophylla*. Each group of diggings was made under as similar topographical conditions as possible.

The soil samples used for analyses were oven dried at 105°C, then passed through a 1 mm sieve. This was used instead of the customary 2 mm sieve in order to exclude the small pieces of dry plant material. As the soil proper contained only a negligible amount of particles larger than 1 mm, this did not materially affect the final results.

Total soluble salts were determined by evaporation of the water extract, chlorine— by titration with silver nitrate, and organic matter by the wet combustion method (Piper 1944).

Plant analysis

Analysis of the salt crust covering the shoots was made as follows: about 10 g of green shoots were thoroughly shaken with 200 cc distilled water. The solution was analysed for total soluble salts and chlorine content by the method described. The soluble salt content *within* the washed plant material was analysed by grinding to powder 10 g of an oven dried sample and boiling it in 200 cc of distilled water. The water extract was analysed as above. All results have been calculated per gram by weight of plant material.

RESULTS

(1) *Soil composition as affected by Tamarix trees*

(*a*) *Total soluble salts*. Table I shows that under the canopy total soluble salts content is significantly higher than in the open, in spite of the considerable variability of the data. The effect of the tree on the salt content decreases with the depth.

TABLE I

Means of total soluble salts under the canopy and in the open,
in parts per million

Depth	Under the canopy	In the open	Difference
0 cm	1201 ± 345	480 ± 120	$721** \pm 299$
40 cm	1198 ± 216	512 ± 102	$678** \pm 250$
80 cm	859 ± 187	490 ± 78	$368** \pm 157$

(b) *Chlorine content*. The differences between the chlorine content under the canopy and in the open are even more striking. As shown in Table II where chlorine is calculated as percentage of total soluble salts, it is especially high under the canopy, at 40 cm and 80 cm.

TABLE II

Means of chlorine percentages within total soluble salts under the
canopy and in the open

Depth	Under the canopy	In the open	Difference
0 cm	4.9 ± 1.8	2.4 ± 1.0	$2.6* \pm 2.5$
40 cm	18.2 ± 6.3	3.0 ± 1.0	$15.1** \pm 6.6$
80 cm	16.4 ± 5.4	3.5 ± 1.1	$12.8** \pm 4.9$

(c) *Organic matter*. Table III shows the mean organic matter content in samples used for determination of total soluble salts and chlorine. In the upper layer there is under the canopy a significantly higher amount of organic matter compared with the open. There is no such effect at 40 cm and at 80 cm.

TABLE III

Means of % organic matter under the canopy of Tamarix trees and in
the open

Depth	Under the canopy	In the open	Difference
0 cm	0.21 ± 0.06	0.10 ± 0.06	$0.11* \pm 0.11$
40 cm	0.09 ± 0.04	0.06 ± 0.02	not significant
80 cm	0.06 ± 0.01	0.05 ± 0.04	not significant

(2) *Soil composition as affected by age of trees*

After selecting three different trees of various dimensions, total salt, chlorine and organic matter content of the soil under them were examined. The height of the biggest tree was 10 m and its diameter at breast height 80 cm. With the aid of an increment borer we found that the average width of the 50 outermost growth

*   Significant at the 0.05 level.
** Significant at the 0.01 level.

rings was 3 mm. This leaves a distance of 20—25 cm extending from the 50th ring
to the core, where the number of the growth rings was not determined.

The age of the medium sized tree was estimated by means of the increment borer
to be 35—40 years. The smallest tree was known to be 5 years old.

(*a*) *Total soluble salts*. Figure 1 plots the total soluble salts content under these trees
against depth for each tree separately. It may be seen that there is a high amount
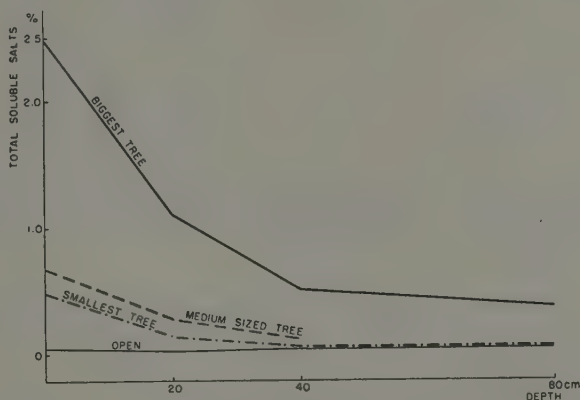of salts under the oldest tree and smaller amounts under the younger ones.

Figure 1
Total soluble salts content of the soil under Tamarix trees of various ages.

(*b*) *Chlorine*. Table IV shows chlorine content under the same group of trees. As
shown above (Table II), there is a strong accumulation of chlorine under the canopy,
but the concentrations under trees of various ages are of the same magnitude.
No age effect is evident.

TABLE IV

*Chlorine % of total soluble salts in samples from under trees of various ages together with samples
from the open*

Depth	Under biggest tree	In the open near biggest tree	Under inter-mediate aged tree	Under youngest tree	In the open near young tree
0 cm	28.0	3.3	28.2	28.6	2.9
20 cm	28.8	1.8	29.3	34.6	0.0
40 cm	33.8	1.4	21.9	23.6	1.6
80 cm	41.2	1.6	—	2.0	3.2

(*c*) *Organic matter*. Figure 2 represents organic matter content under trees of various
ages. Evidently, the upper layer of the soil under the biggest tree contains much

Figure 2
Organic matter content of the soil
under Tamarix trees of various ages.

TABLE V

*Comparison between individual values of total soluble
salts in soils under Acacia, Tamarix and in the open, in
parts per million*

Site No.	Depth	Acacia	Open	Tamarix
9	0	590	460	740
	40	410	400	720
	80	440	670	1160
10	0	620	700	890
	40	520	520	870
	80	460	520	990
11	0	440	910	2420
	40	520	750	2130
	80	470	720	1450

more organic matter than the deeper layers (compare Table III). There is also some age effect.

(3) *Soil composition as affected by Acacia trees*

Total soluble salts, chlorine and organic matter content under *Acacia cyanophylla* trees are compared in Tables V—VII with those under Tamarix and in the open.

The tables show that there are no marked differences between the soil under Acacia and in the open.

(4) *Plant analysis*

Total soluble salts and chlorine content were determined in green shoots and dry litter. Data for green shoots include amount of salts in washing of shoots and whole shoots separately. The data are represented in Table VIII — which also shows the chlorine content calculated as percent of total soluble salts. There is a sharp decline in the chlorine/total soluble salts ratio in the litter as compared with the green shoots.

TABLE VI

Comparison between individual values of chlorine % of total soluble salts in soils under Acacia, Tamarix and in the open, in parts per million

Site No.	Depth	Acacia	Open	Tamarix
9	0	2.2	1.3	2.6
	40	3.2	1.5	3.5
	80	3.0	3.0	8.1
10	0	1.1	1.8	9.1
	40	7.1	2.4	12.9
	80	2.8	1.4	1.4
11	0	1.5	0.8	4.4
	40	4.8	0.9	22.8
	80	13.2	2.8	17.2

TABLE VII

Comparison between individual values of organic matter percentages in soils under Acacia, Tamarix and in the open

Site No.	Depth	Acacia	Open	Tamarix
9	0	0.10	0.21	0.28
	40	0.11	0.03	0.10
	80	0.00	0.00	0.04
10	0	0.07	0.10	0.15
	40	0.00	0.00	0.03
	80	0.09	0.00	0.03
11	0	0.07	0.00	0.14
	40	0.04	0.03	0.03
	80	0.00	0.00	0.14

However, these values are quite arbitrary, as they are likely to change considerably in either direction according to different frequencies and intensities of rain and dew.

TABLE VIII

Total soluble salts and chlorine in fresh Tamarix shoots and dry litter (percent dry weight)

	Total soluble salts		Chlorine		Ratio $\dfrac{chlorine}{sol.\ salts} \times 100$	
	Green shoots	Dry litter	Green shoots	Dry litter	Green shoots	Dry litter
Extract of shoots	19.70	14.50	3.04	0.82	15.4	5.6
Washing of shoots	4.18	—	0.72	—	17.2	—

DISCUSSION

The above data show clearly that there is a marked influence of Tamarix trees on soil composition, especially on soil salinity (Table I). The mean values of total soluble salts under the canopy are twice to three times as high as the mean values in the open. In no pair of samples does the amount of total soluble salts in the open exceed the amount under the canopy. The difference between the mean values is highly significant. Also, total soluble salts decrease with increasing depth under the canopy. This is to be expected if the litter and dew drops dripping from the tree are the source of these salts. By way of comparison, we cite Fireman and Hayward's (1952) data concerning total soluble salts under *Sarcobatus vermiculatus* in the Escalante Desert, Utah. Their results, in terms of conductivity of soil extract, show that the surface soil under the bush had a conductivity of 9.9 mmhos/cm as against 0.6 mmhos/cm in the open. Corresponding values for a depth of 30 cm were 4.4 and 0.5 mmhos. The values for a smaller bush in the surface layer were 1.6 under the bush compared with 0.6 in the open.

Table II shows that the chlorides make up an important part of the soluble salts added to the soil under the canopies. The chlorine content, calculated as percentage of total soluble salts in the soil, is from two to six times higher than in the open In addition there is a greater accumulation of chlorine at 40 and 80 cm than at the surface. This can be readily explained by the higher solubility of chlorides as compared with other salts in the soil. Parallel to this more rapid accumulation of chlorine in the soil there is a rapid loss of chlorine from the litter (Table VIII).

Comparison of the soil composition under Tamarix and *Acacia cyanophylla* (Table V) shows that the Acacia trees have no effect on soil salinity. This may be due the following causes:

(a)   In the trees examined the shed leaves did not form a permanent litter, but were blown away by the wind.

(b)   The probable absence of any appreciable amount of soluble salts in the leaves.

The above information on the influence of *Tamarix aphylla* on soil salinity refers to comparatively young trees only, planted between 1934 and 1949. Although even these young trees had a marked effect on soil salinity, the values under them are not high in comparison with those of other non-saline soils in the Negev. On the other hand, samples collected under trees of greater age showed much higher concentrations. The data of Figure 1, scanty though they are, show that the increase of total soluble salts is clearly related to the age of the trees. They are however insufficient to indicate whether the salinization process will stop at the 2.5 percent point or whether it continues with the ageing of the trees. In this connection it should be mentioned that the salinization of the soil under the biggest tree had a marked influence on the ground vegetation. No plants of any kind were found to grow under the canopy even in the winter of 1953—54, when the ground was densely covered everywhere, while at the periphery — still within the partial influence of the rain and dew water dripping from the canopy, and the falling shoots — there grew almost exclusively halophytic and ruderal species such as *Mesembryanthemum nodiflorum, Pteranthus dichotomus, Bassia muricata, Chenopodium opulifolium* and *Malva parviflora*, which were not found anywhere alse in the vicinity.

Turning now to the influence of Tamarix trees on soil organic matter, the situation becomes somewhat obscure. Table III shows a significantly higher amount of organic matter in the surface layer under the young trees as compared with the open, but in deeper layers no such difference exists. In addition, the absolute amounts of organic matter are very small. Under the biggest tree a much higher amount was found in the surface layer. Under the younger trees progressively smaller amounts are found (Figure 2). Here, too, this amount declines rapidly with increasing depth. Moreover, most of the organic matter seems to be not humus but shoot fragments of various sizes, where the original form of the shoots may still be recognized. It may be concluded that no real humus is accumulated. The above conclusion does not agree with that of Killian (1944) and Vargues (1953), quoted in the introduction.

As in the case of soil salinity, Acacias did not have any effect on soil organic matter content compared with the open (Table VII).

The problem of the salt supply to the trees themselves deserves also some comment. The source of the salts might be the sand itself. In this case, the roots must be endowed with a strong capacity to accumulate salts against a very steep gradient, because, as shown by Ravikovitch (1953) as well as in our work, these sands have very low salt content. Another possibility is that the roots draw their salt supply from a deep layer, probably the underlying loess soil, which contains a higher amount of soluble salts.

The soluble salt content in the shoots varies considerably according to locality. Orshan (1954) gives data on chlorine content in the washings of green shoots of trees growing in saline soil on the shores on the Dead Sea. He gives a value of 1.24% of fresh weight of the shoots, which corresponds to about 2.90% dry weight. In our case, chlorine content of the washings did not exceed 0.72% dry weight.

Finally, it should be mentioned that our results cannot be taken as valid for other regions, where different conditions prevail. Thus, Tamarix in the coastal strip and northern sand dunes probably does not affect the soil in the same way, as rainfall in these regions should be sufficient to wash out any surplus salts accumulating in the upper layers of the soil. On the other hand, one might assume that the same salinization processes are at work also in Tamarix plantations on loess soils, wherever the amount of annual precipitation is of the same magnitude as in the localities described in this paper.

ACKNOWLEDGMENT

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STUDIES ON THE LIFE HISTORY OF *PHYSODERMA LEPROIDES* (TRABUT NON *P. LEPROIDES* LAGERHEIM) KARLING (= *UROPHLYCTIS LEPROIDES* (TRAB.) MAGN.)

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ABSTRACT

The following four stages in the early development of *Urophlyctis leproides* (Trab.) Magn. were established and are described here for the first time: (a) Amoeboid-like granulated cytoplasm appears in the attacked cells. (b) Pseudopodia of the amoeboid cytoplasm spread in the tissues. (c) The cytoplasm undergoes rearrangement to form large compact masses. (d) Rhizomycelia originate from the compact masses.

The formation of turbinate cells and subsequent stages are as described by Jones and Drechsler (1920) and Bartlett (1926).

Neither germination of swarmspores nor penetration into the host were observed, although motile swarmspore-like cells were often seen; there was however no evidence that they represent the swarmspores of the fungus.

The resting sporangia must pass through a period of dormancy (1—2 years) before they can attack a new host. Only very young seedlings are attacked.

First signs of the infection in the host were successfully traced, due to the fact that the fungus attacked leaves rather than root crowns and the changes produced could be easily observed.

INTRODUCTION

Physoderma leproides (Trab.) Karling is a causal agent of crown wart of beet and was first described by Trabut (1894) as *Entyloma leproides* Trab. It was thereafter transferred by Magnus (1897) to the genus *Urophlyctis* and by Karling (1950) to the genus *Physoderma*.

Karling (1950) made a thorough revision of all the species of *Urophlyctis* and *Physoderma* based on living and herbarium material and came to the conclusion that there are no morphological grounds for maintaining *Urophlyctis* as a separate genus; therefore he merged the two under the older name *Physoderma*. This viewpoint is shared by most present-day mycologists.

This fungus was reported by Trabut (1894) on *Beta vulgaris* var. *rapacea* in Algeria; by Reichert (1930) in Palestine; by Chabrolin (1935) in Tunis; by Goidanich (1932) and Ciferri (1950) in Italy. The main area of its distribution is confined to the Mediterranean region. Yet according to Karling (1950) it has also been found

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in Sweden (Lagerheim 1898), in England (Johnson 1909), in Europe in general (Petherbridge and Stiruup 1935) and in Argentine (Speggazini 1909, Hauman-Merck 1915).

In Palestine, according to the records of the Agricultural Research Station, Rehovot, crown wart has been recognized since 1928. All the indications till 1942 are limited to Miqve Israel and Qubeiba (in the vicinity of Tel-Aviv), but since 1947—48 this disease has tended to spread considerably to north and south. The number of affected fields is increasing and so is their extent of infection. According to the observations of the Agricultural Research Station, *Urophlyctis leproides* (Trab.) Magn. attacks forage beet and sugar beet, although sugar beet is much less affected.

This disease is characterized by the occurrence of large galls on the root-crown and leaves of the plant; on the leaves the galls are found on both petioles and blades.

Infected beet are fed to cattle sometimes with the galls and sometimes after removal of the galls, which appear to be harmless to cattle. As is usually the practice, the farmers keep the beets in the open during winter and the affected ones become dry and harden as a consequence of increased evaporation.

So far little work has been done on *Physoderma leproides*.

EXPERIMENTAL PROCEDURE AND RESULTS

In spring 1954 infected forage beet were brought to our laboratory from Kfar Warburg (SE of Tel-Aviv). There were large galls on root-crown and leaves; their form varied according to their position on the plant. The fresh galls were fleshy, but by the end of the summer they dried up and hardened. The galls were cut open, and the resting sporangia of *Urophlyctis leproides*, in form of powdery mass, were dislodged by tapping the galls on a bench.

Experiments on germination

Attempts were made to germinate resting sporangia under various conditions:

(1) At temperatures from 25°—60°.
(2) By transfer from dry to humid air and vice versa.
(3) In agar-agar and beet sap.
(4) In moist soil.
(5) In hanging drops of nutrient solution at different pH.

No germination could be obtained.

Experiments on infection

Resting sporangia from the galls of the same year and of one and two years earlier were used to produce infection of forage beet. These experiments were carried out in four ways:

(1) Infection of beet leaves under a bell-jar.
(2) Infection of seedlings germinated in Petri dishes.

(3) Planting of three weeks old forage beet in soil the surface of which was in-
      fected by resting sporangia.

(4) Sowing seeds of beet in soil infected as above.

Infection of beet was obtained only under the conditions specified under (4), and
then only when the resting sporangia were a year or two years old. The infection
was observed after 3—4 months. Summing up these results on infection, we can
see that only very young seedlings can be attacked and only by resting sporangia
which passed through 1—2 years period of dormancy.

OBSERVATIONS ON U. LEPROIDES IN THE HOST TISSUE

In order to follow the development of the fungus in the host, infected spots were
examined by making serial sections by hand of galls of different ages, mostly from
leaves and in some cases from the root-crowns. The sections were dyed with Cotton
blue.

In very young galls 0.5—3 mm in diameter, early stages in the development of
the fungus could be observed. Granulated cylindrical or globular plasmatic masses
were seen (Figure 1). At a later stage the plasmatic masses become viscous and spread
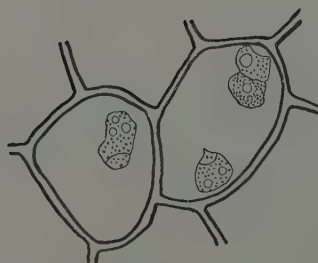
Figure 1
Host cells containing granulated
plasmatic bodies of the fungus.

Figure 2
A moeboid-like bodies send out
pseudopodia which pass through
host cell walls; these bodies are
granulate and contain oil droplets.

by means of pseudopodia into neighbouring cells; in this way large sections of
tissue can be invaded (Figure 2). Subsequently the plasmatic masses increase in
size and become dense, occupying about half the volume of the host's cell (Figure
3). At this stage they stain intensely by Cotton blue. Rhizomycelia grow out of the

compact plasmatic masses and develop turbinate cells at their distal ends (Figure 4). Subsequent development is in accordance with the classical description given by Jones and Drechsler (1920) and Bartlett (1926).

Figure 3
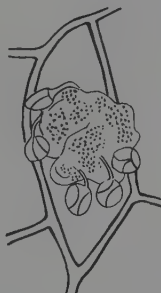Plasmatic masses becoming
dense in a host cell.

Figure 4
Rhizomycelia and turbinate cells arising
from a dense plasmatic mass.

Figure 5
The fungus spreading in the host tissue by
means of rhizomycelia which give rise to
new turbinate cells and resting sporangia.

Figure 6
Ripe resting sporangia shaken out
of a gall.
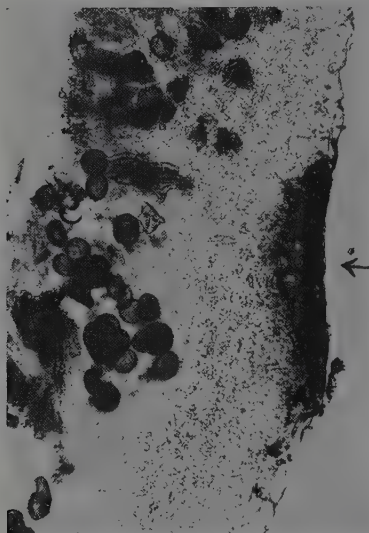
Figure 7
A sorus of resting sporangia in injured host
tissues. Intact vascular bundles are seen
between sporangia. The arrow indicates the
assumed point of penetration where the
dead tissue (dark area) is considered to be
the initial response to the fungus attack.

Figure 8
Spots on the leaf show points of infection;
they appear dark in the photograph due
to the accumulation of anthocyan.

The turbinate cells are known to be uninucleate at first, soon becoming multi-
nucleate. At their distal end is formed a terminal tuft of haustoria. At several places
of the turbinate cells oblique walls cut off a small number (3—5) of uninucleate
peripheral segments, leaving a multinucleate central region. Each peripheral cell
gives rise to a filament — rhizomycelium — which passes through neighbouring
host cells and bears a top-shaped swelling becoming in turn a new turbinate cell
(Figure 5). Meanwhile the multinucleate central region (of each turbinate cell)
buds out a thin-walled cell which grows rapidly and becomes much larger than the
cell from which it originates. The cytoplasm and the nuclei from the central region
pass into it, it becomes thick-walled, bears a crown of haustoria and so resting
sporangia are formed. These are transparent at first, later becoming brown, hemi-
spheric and slightly concave on the side attached to the rhizomycelium (Figure 6).
Finally rhizomycelia and turbinate cells disappear and only resting sporangia are
to be found in the gall tissue (Figure 7).

DEVELOPMENT OF THE GALL

By examining plants infected experimentally we could follow the development of the gall from the point infected by a swarmspore. This point appears at first as a clear spot on the leaf (Figure 8) because some cells around the infected spot died. Sometimes the spots become red because of anthocyan accumulation. Around these dead cells a small wart is formed by frequent divisions in the surrounding epidermal cells (Figure 9). Later, apparently as the spreading fungus destroys the cell walls of the host, the inner tissue starts also dividing intensely. As the wart grows, vascular
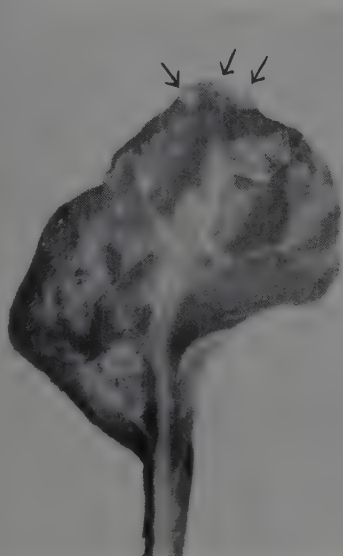
Figure 9
The arrows point towards three early warts, 0.5—2 mm in diameter.

Figure 10
An infected plant leaf bearing galls which tend to fuse together.

tissues grow towards it. The final large gall is formed by the union of many small galls (Figure 10).

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LETTERS TO THE EDITOR

Lipase activity of germinating lettuce seeds*

The existence of a large reserve of lipids together with an active lipase system in germinating lettuce seeds has been previously shown[1,2]. As these investigations in which an acid lipase was studied, were of a preliminary nature, it was decided to study the lipase of germinating lettuce seeds more thoroughly.

The light-sensitive lettuce seeds variety Grand Rapids were used throughout and germinated as described by Poljakoff-Mayber[3]. As the lettuce lipase is a water insoluble enzyme, a powder prepared from acetone-ether defatted seeds was used as an enzyme. Enzyme activity was determined as described by Poljakoff-Mayber[3]. The results are given as increase in acidity (change in titer expressed in ml N/10 NaOH).

Two lipases were shown to exist, one with a peak in activity at pH 7.5, referred to as neutral lipase, and the other an acid lipase with an activity peak at pH 3.5—4.0.

The germination of lettuce seeds is stimulated by light and by thiourea, and inhibited by coumarin. The coumarin inhibition is reversed by light[4]. The effect of all these treatments on the acid and neutral lipase was therefore investigated after various periods of germination. The results are summarized in Figures 1 and 2.

The activity of the neutral lipase rises with germination time in water up to 72 hours both in light and in darkness, The rise begins earlier in the light. Thiourea initially causes a rapid rise in activity followed by a depression after 48 hours. Coumarin prevents the development of neutral lipase activity throughout germination and growth. Light slightly reverses this effect (Figure 1).

The acid lipase shows an initial fall in activity up to 24 hours, followed by a rise after 48 hours when the seeds are germinated in water. In thiourea the initial fall in activity continues throughout germination. Coumarin again prevents any development of lipase activity (Figure 2).

The effect of coumarin on lipase activity in vitro was also tested. Various concentrations of coumarin were added to the reaction mixture containing as an enzyme source powder prepared from seeds germinated for 48 hours. The results are shown in Table I.

The above table shows that the acid lipase is not inhibited by coumarin in vitro. The neutral lipase is inhibited to about 60 percent, but increasing coumarin concentrations do not cause a proportional increase in inhibition.

In conclusion it may be said that two lipases develop during the germination of lettuce seeds. The neutral lipase develops earlier than the acid one, but has a lower activity. The development of both enzymes is prevented by coumarin, but only the neutral one is inhibited by coumarin in vitro. As a result lipase activity in coumarin germinated seeds is prevented.
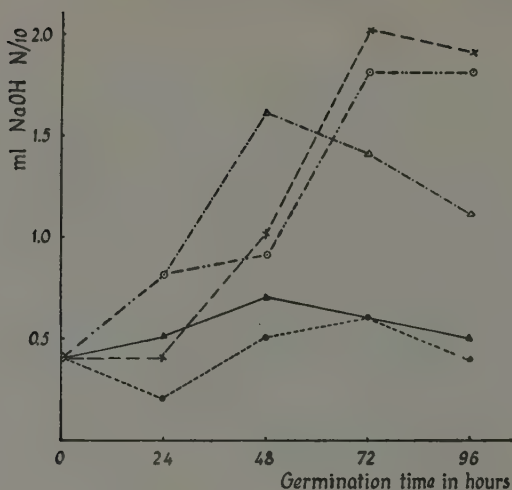
Figure 1

The change in activity of the neutral lipase with germination time.
Seeds germinated:

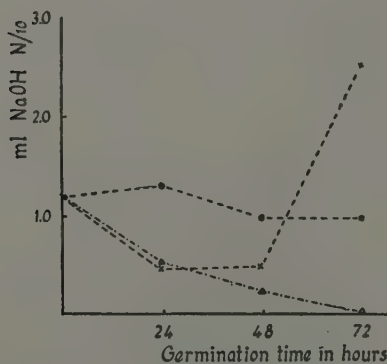| in water in the dark | × — — — — × |
in water in the light	O — .. — .. — O
in coumarin 10 mg % in the dark	● — — — — ●
in coumarin 10 mg % in the light	▲ ———— ▲
in thiourea 125 mg % in the dark	△ —.—.—.—△

Figure 2

The changes in the acid lipase with germination time.
Seeds germinated:

in water in the dark	× — — — — ×
in coumarin 10 mg % in the dark	● — — — — ●
in thiourea 125 mg % in the dark	△ —.—.—.—△

TABLE I

The effect of coumarin on the activity of the neutral and acid lipases in vitro
(from seeds germinated for 48 hours in the light).

Coumarin conc. (mg %)	Lipase activity as % of control	
	Neutral	Acid
0	100	100
2.5	46	—
5	46	—
10	30	100
15	38	—
20	38	100
25	31	108
30	31	125

The acid lipase is thiourea inhibited, despite the fact that thiourea stimulates germination. Presumably the acid lipase is not directly involved in the initial germination process. The fall in neutral lipase activity in thiourea germinated seeds after 48 hours and the almost complete absence of acid lipase activity is paralleled by an inhibition of seedling growth.

ACKNOWLEDGMENT

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Jerusalem

## A new species of R i c c i a from Israel

A new species of *Riccia* was collected by Miss. S. Nachmony during a survey of mosses and liverworts of Israel. It has now been identified, and its description is as follows.

Riccia (*Ricciella*) **palaestina** S. Arn. sp. nov.

affinis *R. rautanenii* Steph. (Bull. Herb. Boiss. 1895, p. 374), qua sporis minoribus, lamellis tenuioribus, stilidio longiore, colore glaucius viridi differt.

Type locality: Israel, Dead Sea area, Nahal Arugot (Wadi Areje), 2 km south-west of Ein Gedi, on muddy flat banks of stream, leg. S. Nachmony, 6.III.1955, No. 83*.

Dioica?, major, pallide viridis, rosulas 3 mm, latas formans, fronde $\frac{1}{2}$—$1\frac{1}{2}$ mm crasso, cavernosa, cavernae angustae. Sporae pallide brunneae, 40—50μ in diam., lamellatae, ala 2—3μ lata.
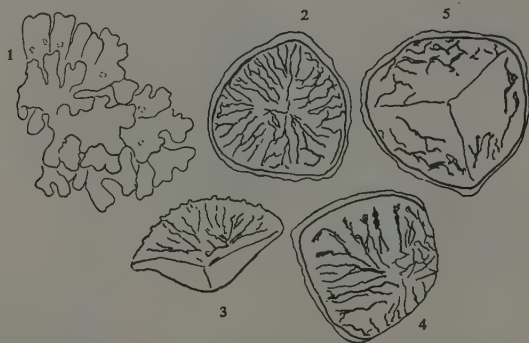
Figures 1—5. *Riccia palaestina* S. Arn. sp. nov. Nachmony No. 83.
1. Thallus, dorsal view.   2—4. Spore, optical sections.   5. Spore, surface view of inner face·

Dioecious?, forming irregular rosettes up to 3 mm or more in diameter. Lobes repeatedly dichotomously branched, overlapping laterally, pale glaucous-green and remaining green or becoming whitish-brown or spongy with age, margins pale green, the sporogonia producing low protuberances, frequently somewhat darker coloured. Thallus 0.5—1.5 mm thick, with one layer of narrow air-chambers situated upon a shallow basal tissue 3—8 cells thick. Epithelium cells thin-walled, about $30 \times 30\mu$, soon destroyed. The ventral surface of the thallus is entirely and very closely attached to the substratum by very numerous and long tuberculate and smooth rhizoids. No ventral or apical scales can be detected. Archegonia sparse, the neck pale brown

and protrudes slightly from the thallus surface. Sporogonia about 0.8 mm in diameter. Spores separating at maturity, somewhat angular, pale brown, variable in markings, outer surface with thin ridges, generally converging towards the centre, inner surfaces with irregular, thin, brown ridges. Wing of the spores thin, 2—3μ wide, slightly crenulate to almost smooth. Spore diameter 40—50μ. Antheridia not observed.

Closely related to *R. rautanenii* Steph. but differs from the latter in the following characteristics: the spores are smaller, the ridges thinner, the archegonial neck longer, the colour more glaucous-green.

During this survey Miss Nachomony also found some specimens of Riccia terracianoi Gola, known up to now only from Abyssinia. As this species is not well known, we give here drawings of its spores.
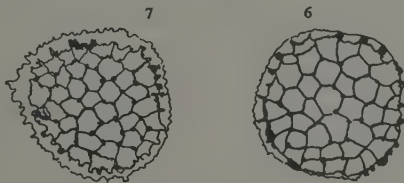
Figures 6—7

Riccia terracianoi Gola, det. S. Arn. Spore, surface views, diameter 60μ, areola 8—10μ.
6. Israel, Shefela, Na'an, Nachmony No. 81.*)
7. Israel, Upper Galilee, Wadi Qarn, Nachmony No. 80.*)

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Centrallasarettet, Gävle, Sweden

*) The species is deposited at the Herbarium of the Hebrew University in Jerusalem.

OBITUARY

LOTTE HEYMANN-HERSCHBERG
1918—1956

On August 17, 1956, with the premature death of Dr. Lotte Heymann-Herschberg, a great expert on citrus nutrition, science in Israel suffered a very heavy loss.

Born in 1918 in Germany, she lost her father in her childhood, and racial discrimination induced her to leave her country of origin. At the age of 18, she joined the ranks of Jewish youth preparing themselves for life in Palestine by agricultural training. In 1939, she emigrated to this country and settled in Kibbutz Shaar Hanegev. However, her great interest in the scientific foundations of agriculture induced her to leave the Kibbutz and to register in 1940 as a student of agriculture at the Hebrew University. After graduating with great distinction in 1944 from the new Institute of Agriculture, she a little later joined the staff of the Agricultural Research Station at Rehovot, in the Division of Citriculture. She specialized in the study of nutrient requirements of citrus trees in Israel, elaborating leaf analytical methods for their determination and the practical application of macro- and micronutrients in the groves. In 1945 she married Philipp Herschberg, a distinguished farmer, and bore children.

Her first publications aroused the interest of Mr. Morel, a Jewish citrus grower in Florida who had developed a private research laboratory for the solution of problems of citrus fertilization. He supplied the division with modern research equipment which was later on further supplemented with the help of the U.S. Operations Mission to Israel. She obtained a fellowship for research at the Citrus Experiment Station in Riverside, California, where she worked in the laboratory of Prof. H. D. Chapman, cooperating with Dr. Wallihan on the absorption of zinc into the cuticle of citrus leaves and its translocation to other organs. On her way back home, she lectured in Paris at the Eighth International Botanical Congress. In America, she underwent an operation on a malignant tumour, and after her return it soon became apparent that her life could not last much longer. Fully cognizant of her bitter fate, she went on working, as if nothing had happened, smiling to her family, colleagues and friends, and not showing the least symptoms of physical or moral weakness. Three months before her death, she charmed her audience in the agrotechnical section of the Fourth International Congress of Mediterranean Citrus Growers at Tel Aviv, where French and Spanish experts took unusual interest in her lecture on micronutrient deficiencies. More unpublished work has been left by this highly gifted and very energetic student.

Lotte Heymann, a smart young lady with an elegant, slim figure, smooth black hair and large dark eyes, though shy and very reserved, won the love of her friends in the Old and New World by her kindness and modesty, and their respect for her creative energy and will-power, as well as her ingenious critical capacities. The present writer who deplores her death with bitter emotion, considered her as one of his few outstanding pupils. It will be very difficult to replace her.

In her Master's thesis[1] Heymann showed that rooting of certain grape-vine root-stocks, as *Solonis* x *Rupestris* 216–3 or *Rupestris* du Lot, could be improved by synthetic growth substances, like chlorophenoxy and naphthoxy acetic acids. She also investigated the effect of these substances on the growth of the oat coleoptile[2].

Her doctorate dissertation[4,5] was devoted to the critical examination of foliar analysis of the Shamouti orange which had been tentatively used and found interesting for practical purposes by the present author. She showed that the method is suitable for the establishment of the tree's nutritional status in nitrogen and phosphorus, and less laborious than soil sampling where more repetitions are required. Much attention was devoted to the development of a correct sampling method in agreement with the age of the leaves, their position on the tree and the season[4,6]. Also, soil and rootstock influences were investigated[7]. The correct interpretation of the results was found to presuppose due consideration of the pronounced N/P antagonism prevailing in citrus nutrition. Thus, not only excess of N or K, but also the disturbance of the N—P equilibrium by overfeeding with easily available phosphorus led to the production of coarse fruit of low quality[5]. Standards of N- and P-content for leaves of grapefruit, lemon and clementine mandarin were established[7,11]. A field experiment on N-fertilization of the Shamouti orange[8] led to the conclusion that overfeeding with nitrogen raises the N-content of the leaves, without raising the yields, fruit quality becoming adversely affected. Thus, the results of earlier local scientists, as Winik, warning against the exaggerated use of mineral nitrogen could be corroborated, while the merit of foliar analysis was shown to rest mainly in the establishment of critical, low figures marking the upper limit of the deficiency range.

Chlorosis produced by magnesium deficiency, a phenomenon which was previously overlooked in citrus groves, proved to be of great practical importance but difficult to cure since the mineral was not absorbed from the soil. Heymann's careful experiments[5] showed that the tree's condition improves very much after repeated spraying with magnesium sulphate, especially when active compounds of zinc, iron, copper and manganese are added. Recently, this could be replaced by dusting with magnesium sulphate as a powder[14].

"Mottle leaf", another citrus chlorosis of great economical importance which is caused by zinc deficiency, was shown to respond to both soil applications and spraying. But recently, Heymann found that the mineral is also absorbed if the trees are dusted with zinc oxide mixed with sulphur which is generally used for the control of mites[10,12].

The absorption of zinc and other minerals by the leaves and its transport into the interior through the heavily cutinized external walls of the epidermis represents a difficult physiological problem which Heymann was very eager to study. This was difficult under the conditions of Lotte's laboratory. Thus, she was happy to do it at Riverside. The recently published report of Heymann-Herschberg and Wallihan[13] on their work with radioactive zinc, shows that it did not result in the detection of the physico-chemical mechanism of zinc absorption and transport, but paved the way to it by exact statements regarding its direction and velocity and the influence of leaf age on both.

In unpublished work, Heymann studied penetration of phosphates into the soil and its influence on leaf composition.

A thorough study of her publications reveals that Heymann attained a profound insight into her problems and their practical aspects. We mention her excellent paper read at the Paris symposium on foliar analysis[9] and her recent survey of the nutritional status of citrus groves in Israel[11]. In the latter, she was able to show that application of phosphorus, potash and lime in mature groves is often unjustified, while magnesium deficiency is widespread and pronounced in groves producing large and coarse fruit. The latter observation might prove to be of great practical importance, as well as her warning against indiscriminate use of potash which might disturb the nutritional balance by impairing the absorption of divalent cations.

Recent results of investigations into the treatment of iron and manganese deficiencies, boron deficiency and excess are summarized in her lecture before the Citricultural Congress at Tel Aviv[14], while her experiments on the application of arsenic for earlier ripening of Shamouti oranges and grapefruits still await publication.

The twelve years of her work on the fertilization of citrus groves in Israel resulted in a decisive step forward towards the final solution of its complicated problems and must be considered as an important and lasting contribution to both theoretical and applied science.

H. R. OPPENHEIMER

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